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December 2006

Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain

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Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain

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9. Remarks

Appendix B includes one compact disc titled *EXCEL Qual Files for Temp at MEDA Stations 12 and 26 Jan93-Dec04* (VER00). The disc contains four compressed folders: *MEDA 12 QualTemps_Sep_06.zip, MEDA 26 QualTemps_Sep_06.zip, MEDA 12 Preliminary Summary_93_04.zip, MEDA 26 Preliminary Summary_93_04.zip.*

Appendix F includes one compact disk that consists of a set of Excel® roadmap files pointing to the Excel® files used to create the figures (and any related tables) discussed in the report. The compact disc is titled *EXCEL Workbooks Used to Create Figures and Related Tables Discussed in Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain (ANL-MGR-MD-000015 REV00).*

This report was initiated under the BSC management and support staff who provided significant effort, support and guidance in the production of the REV00 product.

The following individuals contributed to this document: Peter Persoff, Dale Ambos, Joey Seamands, Phil Rogers.

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ACRONYMS AND ABBREVIATIONS

ARL	Air Resources Laboratory
agl	above ground level
amsl	above mean sea level
BSC	Bechtel SAIC Company, LLC
DTN	data tracking number
MEDA	meteorological data acquisition
NAD	North American Datum
NOAA	National Oceanic and Atmospheric Administration
NTS	Nevada Test Site
QA	Quality Assurance
SORD	Special Operations Research Division
UTM	universal transverse mercator
WBAN	Weather Bureau, Air Force, and Navy
YM	Yucca Mountain

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1. PURPOSE

The purpose of this analysis is to identify, extract, and reformat weather (meteorological) data that is appropriate for use as input to an infiltration model, within the Yucca Mountain region. The analysis uses relevant meteorological data (e.g., precipitation and temperature) from source stations, and reformats or converts the data into a form suitable for the generation of meteorological conditions for a 10,000-year future climate in the Yucca Mountain region. This analysis falls under the guidance of *Technical Work Plan for: Infiltration Model Assessment, Revision, and Analyses of Downstream Impacts* (BSC 2006 [DIRS 177492], Task 1). Planning and preparation of this report was initiated under the Bechtel SAIC Company, LLC (BSC), Quality Assurance (QA) Program. Therefore, forms and associated documentation prepared prior to October 2, 2006, the date this work transitioned to the Lead Laboratory, were completed in accordance with BSC procedures. Forms and associated documentation executed after October 2, 2006, were prepared in accordance with Lead Laboratory procedures. The selected meteorological site and station locations, and the types of weather data extracted from records of said locations (Sections 1.1 to 1.4), are used to represent the range of present-day and future climate conditions within the Yucca Mountain vicinity. Meteorological data extracted from locations outside the Yucca Mountain vicinity are meant to approximate climate conditions within the area during a projected monsoonal and glacial transition climatic period that is expected to occur within the next 10,000 years. These “future proxy climate locations” are listed in *Future Climate Analysis* (BSC 2004 [DIRS 170002], Table 6-1). Weather data presented in this analysis will subsequently be abstracted by the downstream user as inputs to an infiltration model (BSC 2006 [DIRS 177492]).

Meteorological conditions described herein were measured and recorded within limited timeframes, and within a limited spatial location. Thus, the data, alone, have limitations in that meteorological conditions represent a finite timeframe and locale. Any extrapolation of data used to represent meteorological conditions over a broader area, or over an expanded timeframe, must be justified by the downstream user. Data products of this analysis may be used to perform tasks identified in the technical work plan (BSC 2006 [DIRS 177492]).

1.1 SITE-SPECIFIC METEOROLOGICAL STATIONS LOCATED WITHIN THE CONTROLLED AREA

There are nine meteorological monitoring stations located within the controlled area of Yucca Mountain. These stations measure precipitation, temperature, barometric pressure, wind speed, and relative humidity, and are maintained by the Yucca Mountain Project. Data collected from six of the nine stations (Yucca Mountain [YM] Sites 1, 2, 3, 6, 8, and 9) are inputs to this analysis. These data were collected under an approved quality program that included periodic instrumentation and procedural checks to maintain data integrity. As such, the data have “qualified” status (i.e., their “qualification status” is “Q”). Locations of the six sites are described in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722], Table A-1).

YM Sites 1, 2, 3, 6, 8, and 9 were selected from the nine for this analysis based on their relatively close proximity (within a 10 to 12 km radius of the repository footprint) and their placement at various elevations above and below the elevation of the repository. Based on this, YM Sites 1, 2, 3, 6, 8, and 9 are indicative of the spatial variability in climatic conditions that affect infiltration within the Yucca Mountain region. With the exception of YM Site 8, hourly values for precipitation, temperature, barometric pressure, relative humidity, dew point temperature, and wind speed were extracted from the collected qualified data. Only precipitation and temperature data were extracted for YM Site 8. The hourly data were used to calculate daily summaries for each site in the following data sets:

- Minimum daily temperature
- Maximum daily temperature
- Daily precipitation
- Average daily relative humidity
- Average daily dew point temperature
- Average daily barometric pressure
- Average daily wind speed.

Dew point temperatures were measured only at YM Site 1, and only from 1993 through 1998.

1.2 PRECIPITATION STATIONS MAINTAINED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) maintains numerous stations, within 40 km of the repository, that have kept daily precipitation records. For this analysis, precipitation records were extracted from the data recorded at four NOAA stations: Cane Springs, Area 12, Site 4JA, and 40MN. These four stations are part of a precipitation gauge network operated by the NOAA Air Resources Laboratory (ARL) Special Operations Division (SORD) at the Nevada Test Site (NTS) ("NOAA/ARL/SORD"). In addition, precipitation and temperature data were extracted from the NOAA Cooperative Observer (COOP) station at Amargosa Farms–Garey. These five stations were selected based on their elevation, continuity of recorded data, and their proximity to the repository.

Precipitation data from Amargosa Farms–Garey were selected because the station is at the lowest elevation (747 m amsl [above mean sea level]). Precipitation data from Area 12 were selected because the station is at the highest elevation (2283 m amsl). Amargosa Farms–Garey is the only station that collected temperature data. Precipitation data from Cane Springs, 40MN, and Site 4JA were selected because the elevations of the stations were within a few hundred meters (above or below) of the repository elevation. Data from these stations are used to assess the spatial variability in precipitation, and the correlation between precipitation and elevation.

1.3 METEOROLOGICAL DATA ACQUISITION STATIONS, LOCATED WITHIN THE NEVADA TEST SITE, REPRESENTATIVE OF PRESENT-DAY CLIMATE CONDITIONS

Numerous meteorological stations located on and near the NTS have been maintained since 1957. Original stations, initially operated by the U.S. Weather Bureau, have been replaced with the current network of stations, denoted as meteorological data acquisition (MEDA) stations, which are operated by NOAA/ARL/SORD. The MEDA stations collect a suite of meteorological data. The NOAA/ARL/SORD supports NTS operations through the collection of MEDA data.

Temperature data collected from MEDA 12 and MEDA 26 are used in this analysis to develop daily values of minimum, maximum, and average temperatures for each location. The Western Regional Climate Center, which monitors MEDA weather stations, has a posted disclaimer on its web site, explaining that data may be subject to error because of possible instrument calibration issues, equipment failure, data transfer problems, or other similar anomalies. In addition, for MEDA data, Yucca Mountain Project records include "read me" files that contain a disclaimer statement (that the data are provisional, that a thorough quality check has not yet been completed, and that users should check the data for appropriateness of use) (Ambos 2006 [DIRS 177708]). In order to use the MEDA 12 and MEDA 26 temperature data, the data required and received qualification for use in this report for this analysis. Thus, the MEDA 12 and MEDA 26 data used in this analysis (DTN: SN0603NTSMEDAW.001 [DIRS 176721]) have been qualified in accordance with SCI-PRO-001, *Qualification of Unqualified Data*, and SCI-PRO-005, *Scientific Analysis and Calculations*.

1.4 METEOROLOGICAL DATA FROM STATIONS REPRESENTATIVE OF FUTURE CLIMATE CONDITIONS WITHIN THE YUCCA MOUNTAIN REGION

Seven locations, described in *Future Climate Analysis* (BSC 2004 [DIRS 170002], Table 6-1), were selected to represent the precipitation and temperature ranges within the Yucca Mountain region for future proxy climate locations.

The future proxy climate locations that represent a monsoonal climate at Yucca Mountain are Nogales, Arizona, and Hobbs, New Mexico. The glacial transition future-proxy climate locations are Spokane, Rosalia, and St. John in Washington State; Beowawe, Nevada; and Delta, Utah. Precipitation and temperature data from the NOAA meteorological weather stations at these seven locations, recorded between 1947 and 2004, have been extracted and reformatted (Section 6.2).

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2. QUALITY ASSURANCE

Development of this analysis and supporting calculation activities are subject to the Yucca Mountain Project Quality Assurance Program, as described in *Quality Assurance Requirements and Description* (DOE 2006 [DIRS 177092]) and indicated in the technical work plan (BSC 2006 [DIRS 177492], Section 8.1). Planning and preparation of this report was initiated under the BSC QA Program. Therefore, forms and associated documentation prepared prior to October 2, 2006, the date this work transitioned to the Lead Laboratory, were completed in accordance with BSC procedures. Forms and associated documentation executed after October 2, 2006, were prepared in accordance with Lead Laboratory procedures. Approved quality assurance procedures have been used to conduct and document the activities performed for this analysis. Methods used to control the electronic management of data are also identified in the technical work plan (BSC 2006 [DIRS 177492], Section 8.4). The process used to qualify data was conducted and documented following SCI-PRO-001, *Qualification of Unqualified Data*.

This analysis examines data used to evaluate the performance of natural barriers that are important to waste isolation, as defined in LS-PRO-0203, *Q-List and Classification of Structures, Systems, and Components*. The analysis generates outputs for use in assessing present-day and future climatic conditions. Present-day and future climatic conditions are inputs to the infiltration model for the unsaturated zone, which is a component of the upper natural barrier identified in *Q-List* (BSC 2005 [DIRS 175539], Table A-1). The Safety Category in the *Q-List* is denoted as SC. This analysis contributes to evaluations and modeling data used to support postclosure performance assessment.

The conclusions of this analysis do not affect the repository design or engineered features that are defined in LS-PRO-0203 as important to safety.

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3. USE OF SOFTWARE

3.1 EXEMPT SOFTWARE

The software applications used to support the analysis activities described in this document are Microsoft (MS) Access, Version 2003 Service Pack 2 (SP2); Microsoft Excel, Version 2003 SP2, and MATHCAD Version 13. These software applications are commercial-off-the-shelf (COTS) applications that have been determined to be exempt from qualification or documentation in accordance with Section 2 IM-PRO-003, *Software Management*. The use of these software applications will be in accordance with SCI-PRO-005, Attachment 2, Section 3. These software applications will use the Windows XP Professional operating environment.

The MS Excel 2003 SP2 and MATHCAD V. 13 associated functions, formulas, inputs and outputs have been documented in sufficient detail in Appendix C of this document. This required information will provide an independent reviewer the ability to reproduce or verify the results by visual inspection or hand calculations without recourse to the originator.

3.2 QUALIFIED SOFTWARE

The baselined software item CORPSCON (CORPSCON V.5.11.08 [DIRS 155082], STN: 10547-5.11-08-00) will be used for this analysis. CORPSCON converts geospatial (map) data coordinates to a common coordinate system. This software item was used on the qualified operating environment, Windows NT 4.0. CORPSCON is used convert between geographic, state plane, and universal transverse mercator (UTM) coordinate systems. For consistency, all meteorological station locations need to be listed using the same coordinate system. In many instances, meteorological station locations were not given as UTM North American Datum (NAD) 27 coordinates. CORPSCON was used to convert meteorological station coordinates from geographical or UTM NAD 83 coordinates to UTM NAD 27 coordinates. The software is consistent with the intended use and within the documented validation range and limitations stated in the qualified documentation for this software item.

The baselined software item EARTHVISION (EARTHVISION V.5.1 [DIRS 167994], STN: 10174-5.1-00) will be used to extract a projected elevation given geographic coordinates as inputs and was used on the qualified operating environment, IRIX 6.5. The software is consistent with the intended use and within the documented validation range and limitations stated in the qualified documentation for this software item.

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4. INPUTS

4.1 DIRECT INPUTS

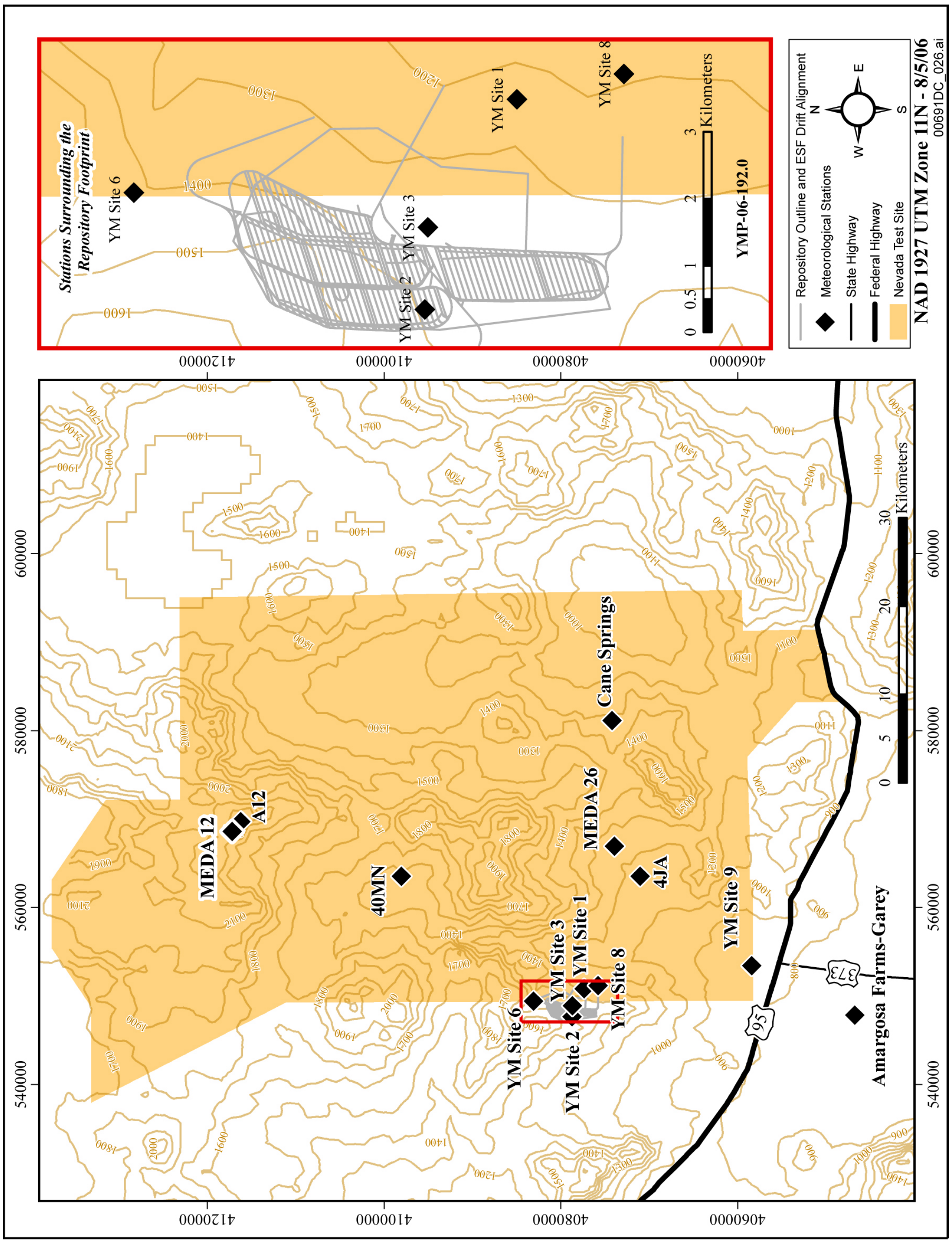
Sections 4.1.1 through 4.1.3 describe inputs used to perform calculations in this analysis.

4.1.1 Site-Specific Meteorological Data

Meteorological data collected at YM Sites 1, 2, 3, 6, and 9, during the period 1993 through 2004, are used as inputs to the calculations in this analysis. A subset of precipitation data collected at YM Site 8 in 2004 is also used as input to this analysis. The six sites from which data were collected have been physically checked frequently to prevent data loss, and have been maintained under the Yucca Mountain Project Quality Assurance Program. YM Sites 1, 2, 3, 6, 8, and 9 are located at various elevations within the modeled area (Figure 4.1-1), and are described in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722], Table A-1). Meteorological data collected from the six sites are appropriate as inputs for assessing spatial variability in climatic conditions within the controlled area that would affect infiltration within the Yucca Mountain region. Source records, with assigned data tracking numbers (DTNs) and corresponding years in which the data were collected, are shown in Table 4.1-1. These data are used as input to the analysis presented in Section 6.1.

Table 4.1-1. Collection Dates and Data Input Files

Year in Which Data Were Collected	Microsoft® Access® File for Hourly Data	Source DTN
1993	Met1993.mdb	MO0312SEPQ1993.001 [DIRS 176092]
1994	Met1994.mdb	MO0312SEPQ1994.001 [DIRS 176093]
1995	Met1995.mdb	MO0312SEPQ1995.001 [DIRS 176094]
1996	Met1996.mdb	MO0312SEPQ1996.001 [DIRS 176095]
1997	Met1997.mdb	MO0312SEPQ1997.001 [DIRS 167116]
1998	Met1998.mdb	MO0206SEPQ1998.001 [DIRS 166731]
1999	met1999.mdb	MO0302METMON99.001 [DIRS 166165]
2000	met2000.mdb	MO0209SEPQ2000.001 [DIRS 166730]
2001	met2001.mdb	MO0305SEP01MET.002 [DIRS 166164]
2002	met2002.mdb	MO0305SEP02MET.002 [DIRS 166163]
2003	met2003.mdb	MO0503SEPMMD03.001 [DIRS 176097]
2004	metdata2004.mdb	MO0607SEPMMD04.001 [DIRS 176098]



Source: Output DTN: SN0612GEOCOORD.001; DTNs: SN0603NTSMEDAW.001 [DIRS 176721] and SN0512NOAADATA.002 [DIRS 176099]; NCDC 1998 [DIRS 135900].

Figure 4.1-1. Meteorological Station Locations Used to Represent Yucca Mountain Present-Day Climate Conditions

4.1.2 National Oceanic and Atmospheric Administration Precipitation Stations for Present-Day Climatic Conditions

Precipitation data from five NOAA stations, collected from 1959 to 2005, have been used as inputs to assess precipitation ranges in the vicinity of Yucca Mountain (DTN: SN0512NOAADATA.002 [DIRS 176099]). Four of the NOAA stations (Area 12, Cane Springs, 40MN, and Site 4JA), whose data sets contain only precipitation records, are located on the NTS. The fifth station, Amargosa Farms–Garey, whose records contain both precipitation and temperature data, is located outside the NTS. Amargosa Farms–Garey temperature data recorded from December 1965 through January 1997 were retrieved from *Summary of the Day Observations: West 1 for Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming* (NCDC 1998 [DIRS 135900]), also referred to herein as the "EarthInfo® summary file." These inputs are used in the analysis presented in Section 6.2.

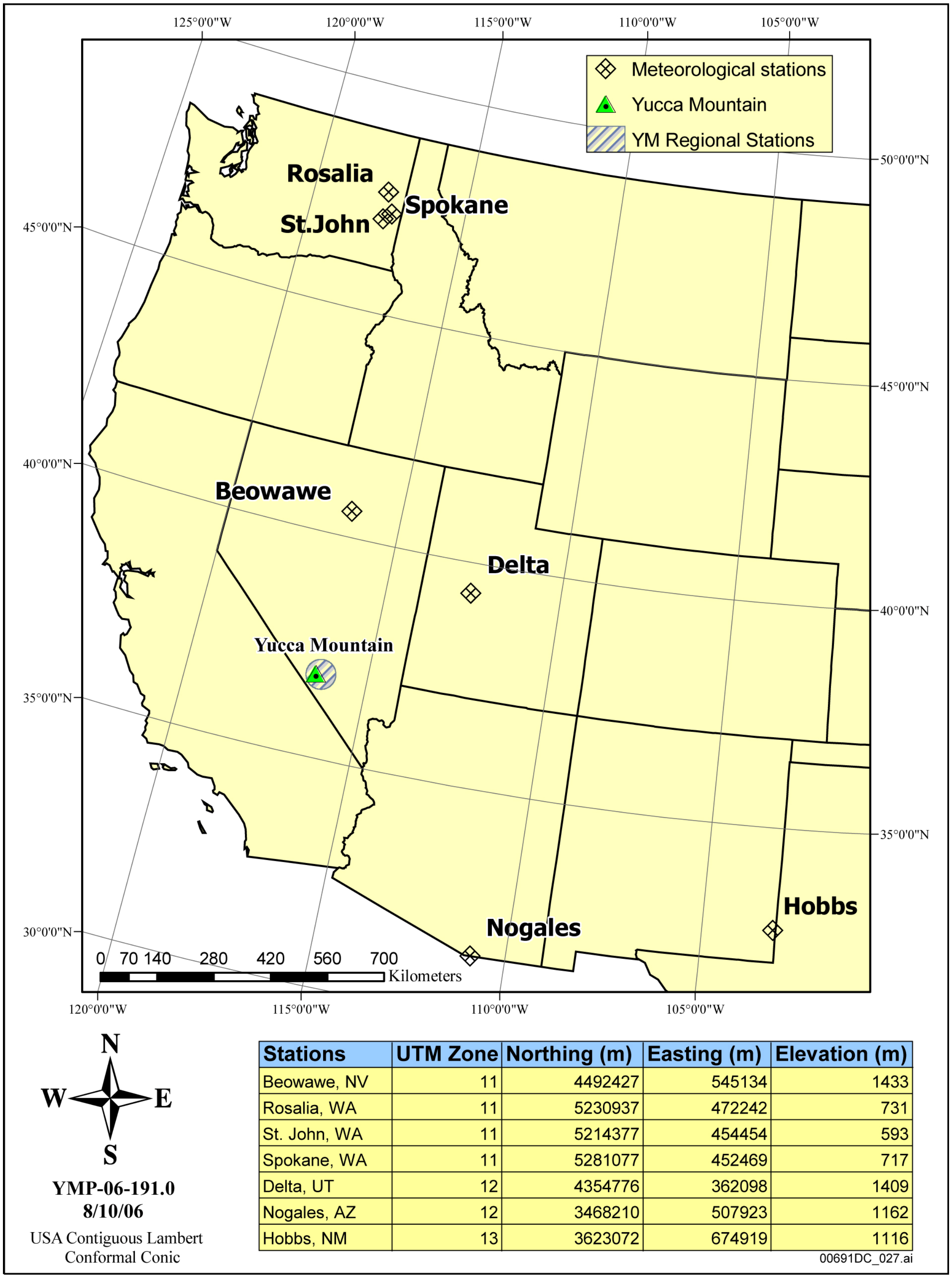
4.1.3 National Oceanic and Atmospheric Administration Weather Stations Used for Proxy Glacial-Transition Climate

Input data (DTN: SN0512NOAADATA.003 [DIRS 176100]) used to develop minimum and maximum temperature and precipitation ranges in the vicinity of Yucca Mountain for future climates are derived from data, collected over various periods from 1947 through 2004, from the following seven NOAA locations (Figure 4.1-2):

- Nogales, Arizona
- Hobbs, New Mexico
- Spokane, Rosalia, and St. John, Washington
- Beowawe, Nevada
- Delta, Utah.

4.1.4 Temperature Data Collected from Meteorological Data Acquisition Stations Located on the Nevada Test Site

Temperature data (DTN: SN0603NTSMEDAW.001 [DIRS 176721]) collected from stations located on the NTS were used as the source for daily values of minimum, maximum, and average temperatures for MEDA 12 and MEDA 26. The temperature data for MEDA 12 and MEDA 26 were then associated with precipitation data measured at the Area 12 and 4JA (located in Jackass Flats) locations, which do not record temperatures. Qualification of MEDA data (for use as input to derive daily temperature values) is included in Appendix A. Temperature plots recorded at MEDA 12 and MEDA 26 for years 1995, 1998, and 2002 (archived in DTN: SN0603NTSMEDAW.001 [DIRS 176721]) are included in Appendix D for comparison purposes between temperatures plotted and recorded at nearby YM Sites during the same time period. The actual files that demonstrate that the recorded temperature data are representative of temperatures at the two sites are recorded in a compact disc titled *EXCEL Qual Files for Temp at MEDA Stations 12 and 26 Jan93-Dec04* (VER00).



Stations	UTM Zone	Northing (m)	Easting (m)	Elevation (m)
Beowawe, NV	11	4492427	545134	1433
Rosalia, WA	11	5230937	472242	731
St. John, WA	11	5214377	454454	593
Spokane, WA	11	5281077	452469	717
Delta, UT	12	4354776	362098	1409
Nogales, AZ	12	3468210	507923	1162
Hobbs, NM	13	3623072	674919	1116

Source: DTN: SN0512NOAADATA.003 [DIRS 176100].

Figure 4.1-2. Locations (as NAD 27 coordinates) of Meteorological Data Used as Inputs in Representing Future Climate Conditions within the Yucca Mountain Region

4.2 CRITERIA

Climate and infiltration activities described herein are subject to regulatory review in accordance with the acceptance criteria of *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274], Acceptance Criterion 2.1 of Section 2.2.1.3.5.3, and Acceptance Criterion 3.1 of Section 2.2.1.3.5.3). The criteria are addressed in Section 7.2 of this report.

4.3 CODES, STANDARDS, AND REGULATIONS

Codes, standards, and regulations applicable to this work are defined in the technical work plan (BSC 2006 [DIRS 177492], Section 3). There are no industrial or technical standards directly applicable to this work activity.

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5. ASSUMPTIONS

Assumptions, approximations, and simplifications related to the treatment of extracted climate data are discussed in Sections 5.1 through 5.3.

5.1 ASSUMPTION 1: METEOROLOGICAL SENSOR LOCATIONS

Temperature values recorded at sensors located at the 10 and 2 m agl (above ground level) elevations are suitable for use in representing the global temperature variability indicative of temperatures for that day, season, and location at Yucca Mountain.

Basis: The selected array of stations is meant to represent the general variability in temperature within the vicinity of Yucca Mountain, given the topographic elevation and positional differences such as ridge tops, valley floors, and slope-face. The temperature data from the selected Yucca Mountain sites were those measured between January 1, 1993, and December 31, 2004. All temperature readings at YM Sites 6 and 9 were measured on sensors located at 2 m agl. Prior to mid-1993, temperature sensors at YM Sites 1, 2, and 3 were recorded on sensors located at 10 m agl. Temperature sensors were activated at a 2 m agl elevation for these stations on the following days. At YM Site 1, temperature sensors were activated at 2 m agl on April 30, 1993, at 2100 hours. At YM Site 2, temperature sensors were activated at 2 m agl on September 1, 1993, at 1300 hours. At YM Site 3, the temperature sensor was activated at 2 m agl on September 1, 1993, at 1600 hours

The change of the temperature measurement height from 10 m agl to 2 m agl for Sites 1, 2, and 3 during 1993 produces a discontinuity in the data record that is less than 2 percent of the overall 12-year period. The magnitude of the impact of temperature differences measured at the various locations varies as a function of topographic exposure, so the effects of temperature relative to positioning of the sensor at the respective sites will be be different. Temperature data from YM Sites 1, 2, 3, 6, and 9 will be used in infiltration simulations as described in the technical work plan (BSC 2006 [DIRS 177492]), to generate a range of temperature values. For purposes of this analysis, the impacts of temperature measurements recorded between 2 m and 10 m agl change is assumed to be small relative to the overall data set and the differences in temperature occurring between different site locations.

Used in: Assumption 1 is used in Sections 6.1 and 6.4.

5.2 ASSUMPTION 2: CORROBORATED METEOROLOGICAL DATA

For qualification purposes, it is appropriate to use meteorological data from Yucca Mountain sites to corroborate unqualified MEDA data from MEDA stations that are located in close proximity to the Yucca Mountain sites.

Basis: The YM meteorological monitoring program complied with the Yucca Mountain Quality Assurance Program throughout the data collection period, and the data are qualified. These processes ensure the integrity of site measurements and meteorological data and, thus, are assumed accurate and representative of climatic conditions in their vicinities.

Meteorological data from YM Sites 1, 2, 3, 6, 8, and 9, located within a few kilometers of nearby MEDA stations, are used to corroborate MEDA data. It is expected that temperatures measured at a MEDA station will show diurnal and seasonal fluctuations similar to those of a nearby Yucca Mountain site, and that measurements taken at a nearby Yucca Mountain site will be within a few degrees Celsius of those at a nearby MEDA station. Therefore, it is appropriate to qualify MEDA temperature data using a corroboration method.

Used in: Assumption 2 is used in Section 6.4 and Appendix A.

5.3 ASSUMPTION 3: SURROGATE PRECIPITATION DATA

Precipitation data recorded from Julian day 34 through Julian day 62, 2004, at YM Site 8 provide an appropriate surrogate for precipitation data recorded at YM Site 1.

Basis: YM Site 8 is only 12 m lower in elevation than YM Site 1, and is located approximately 1.5 km south-southeast of YM Site 1. Therefore, recorded precipitation data at YM Site 8 can be expected to be very similar to recorded precipitation data at YM Site 1.

Used in: Assumption 3 is used in Section 6.1.

6. SCIENTIFIC ANALYSIS DISCUSSION

This analysis provides meteorological data that may be used as input for creating a range of meteorological conditions representative of present-day climate and future climate scenarios within the Yucca Mountain region. The implementation and results of the process will be subsequently documented in a revised infiltration model (BSC 2006 [DIRS 177492]).

The range of present-day climate conditions that could prevail over approximately the next several hundred years is derived from meteorological stations located within a 40 km radius of Yucca Mountain. The meteorological data discussed in Section 6.3 are from locations (referred to as analogue sites) recommended in *Future Climate Analysis* (BSC 2004 [DIRS 170002], Table 6-1), and represent monsoonal and glacial-transition climate conditions at Yucca Mountain. The present-day data, including data from the analogue sites, will be used collectively to represent meteorological conditions that approximate climatic conditions within the Yucca Mountain region over the next 10,000 years.

The data in this analysis provide limited uncertainty in assessing present-day and future meteorological conditions. The limited uncertainty stems from the data being collected during relatively short timeframes, and from the data consisting of "point" measurements. That is, data represent meteorological conditions within a limited spatial locale and timeframe. Therefore, given such limitations, the data by itself will under-represent spatial and temporal uncertainty and variability of meteorological conditions.

Calculations performed on input data are described in Sections 6.1 through 6.4. Results of the analysis are summarized in Section 7. Information and data used to qualify unqualified data are provided in Appendices A and B.

6.1 SITE-SPECIFIC METEOROLOGICAL DATA REPRESENTATIVE OF PRESENT-DAY CLIMATE CONDITIONS

Meteorological data from YM Sites 1, 2, 3, 6, 8, and 9 (output DTN: SN0608WEATHER1.005) represent present-day climate conditions in the Yucca Mountain region. The six sites function as meteorological monitoring stations. Five of the six sites are within a 4 to 5 km radius of the projected repository footprint. The sixth station, YM Site 9, is located approximately 12 km south of the footprint. The sites provide hourly values of precipitation, temperature, barometric pressure, relative humidity, dew point temperature, and wind speed (Section 4.1.1).

With the exception of YM Site 8, hourly data are used to calculate the following:

- Minimum daily temperature
- Maximum daily temperature
- Daily precipitation
- Average daily relative humidity
- Average daily dew point temperature
- Average daily barometric pressure
- Average daily wind speed.

There are three caveats pertaining to the source data (Section 4.1.1): (1) dew point temperature data were only collected at YM Site 1, and only from 1993 through 1998; (2) due to instrumentation problems, precipitation recorded at YM Site 1 during Julian days 34 through 62, 2004, was underestimated. For these 29 days, precipitation data recorded at YM Site 8 was used as surrogate data for YM Site 1. If the downstream user needs to assess any relationships between precipitation and temperature, the user can access the hourly temperature data for YM Site 8 that is included with precipitation data; (3) the geographical coordinates and elevations for the six stations were not considered as qualified in the meteorological data files. Consequently, the geographical coordinates of YM Sites 1, 2, 3, 6, 8, and 9 and elevations for YM Sites 1, 2, 3, 6, and 9 were qualified in Appendix H of this report. Output DTN: SN0608WEATHER1.005 provides meteorological data intended for use as input for present-day climate conditions in infiltration modeling. Output DTN: SN0612GEOCOORD.001 includes the qualified geographical information for these six site stations.

6.1.1 Data Extraction

Meteorological data of YM Sites 1, 2, 3, 6, 8, and 9 are identified by unique DTN identifiers listed in Table 4.1-1, for each associated year. The specific Access™ file for each year is also listed. Hourly measured meteorological parameters, listed in Table 6.1-1, were extracted from these Access™ files, and were then copied and pasted into Excel® worksheets. Parameter selection for this process was performed using the Access™ QUERY function. Data selected via queries for specific weather stations and years, and their associated naming conventions in the Access™ source files, are also listed in Table 6.1-1. In total, six Excel® workbooks (see Table 6.1-2) were created to process the data. These workbooks are contained in output DTN: SN0608WEATHER1.005.

With the exception of the YM Site 8 file, each Excel® workbook noted in Table 6.1-2 contains 12 worksheets. Each workbook represents unique data sets for 12 years of data collection: 1993 through 2004. Worksheets are named by site, year, and frequency of data collection (e.g., a worksheet "S001_93h" contains hourly data collected from YM Site 1 in 1993). These worksheets, containing hourly meteorological measurements for a year, provided input to the summary worksheets used to generate site-specific data for present-day climate conditions (Section 6.1.4). The Excel® workbook with the YM Site 8 data includes four worksheets: one worksheet that includes the hourly precipitation and temperature data recorded in 2004, and three summary worksheets that include daily precipitation and minimum and maximum daily temperature for 2004.

Table 6.1-1. Extracted Yucca Mountain Site Weather Station Data

Data Name	Units	Data Description
SITE	number	Site number
YEAR	number	Year measurements were taken
J_DAY	number	Julian day (1 to 365 [1 to 366 for leap years]) measurements were taken
TIME	hours, minutes	Time at end of period that measurements were taken (hourly average, computed from 0100 hr to 2400 hr)
WS_10	meters per second	Hourly average horizontal wind speed, 10 m above ground [a]
TEMP_2M	degrees Celsius	Hourly average ambient air temperature, 2 m above ground
TEMP_10M	degrees Celsius	Hourly average ambient air temperature, 10 m above ground [b]
BP	millibars	Hourly average barometric pressure [a]
RH	percentage	Hourly average relative humidity, 2 m above ground (YM Site 1 did not record relative humidity for 1993 through 1998)
PCP_TB	millimeters	Hourly total precipitation
DEW_PT	degrees Celsius	Hourly average dew-point temperature, 2 m above ground (dew-point temperature was collected only for YM Site 1, only from 1993 through 1998)

Source: Output DTN: SN0608WEATHER1.005.

[a] Since 1999, YM Sites 3 and 6 have not collected wind speed and barometric pressure data. Consequently, no Access™ file data are available for YM Sites 3 and 6.

[b] At Sites 1, 2, and 3, temperature data recorded during the first portion of 1993 were measured only with sensors located at 10 m agl. During the latter part of 1993, temperature sensors were installed at 2 m agl. The dates and times when the temperature data were first measured at 2 m agl were: Site 1 – April 30, 1993, at 2100 hour; Site 2 – September 1, 1993, at 1300 hour; and Site 3 – September 1, 1993, at 1600 hour. Temperature data reported for Sites 6 and 9 were measured at 2 m agl for the entire period.

YM = Yucca Mountain.

Table 6.1-2. Workbooks from Which Data Were Extracted and Processed

Weather Station	Workbook File Name
YM Site 1	*Site 1_SmyQry_Aug23.xls*
YM Site 2	*Site 2_SmyQry_Aug24.xls*
YM Site 3	*Site 3_SmyQr_ Aug23.xls*
YM Site 6	*Site 6_SmyQry_ Aug23.xls*
YM Site 8	*Site 8_SmyQry_ Aug23.xls*
YM Site 9	*Site 9_SmyQry_ Aug23.xls*

Source: Output DTN: SN0608WEATHER1.005.

YM = Yucca Mountain.

6.1.2 Data Processing

Invalid data within a file are denoted by a designator of “9999.” The first step in processing extracted data was to remove the designators, and replace them with “n/a” designators. This step was accomplished by using the Excel® SEARCH and REPLACE function.

Data in the Access™ files were not always consecutively listed by Julian day. Therefore, a check was performed to ensure that data were listed consecutively, by Julian day. If data were not listed consecutively by Julian day, then the data were corrected by using the Excel® SORT function to sort on Julian day. After sorting was performed, data were plotted to ensure that there were no nonphysical outlier points. If outlier points were found, they were replaced with "n/a" designators.

Using built-in Excel® functions, hourly data were processed over the 24-hour daily cycle, starting with the first hour of the day and ending with the twenty-fourth hour:

- Using the AVERAGE function, daily averages were computed from the extracted 24-hour values.

- Using the MIN and MAX functions, minimum and maximum daily temperature values over the daily 24-hour periods were calculated from extracted hourly data.

- Using the SUM function, cumulative daily precipitation was calculated from hourly data.

Other than precipitation data, if within a single day five or more "n/a" designators were recorded for a measured parameter, then it was deemed that there were insufficient data for that 24-hour period to calculate meaningful averages or minimum and maximum values. Because precipitation is an intermittent and rare occurrence in desert locations, if a day contained more than five "n/a" designators, then professional judgment was used to ascertain whether cumulative precipitation was appropriately calculated. Justification for this approach is presented in Appendix E.

Daily temperature average values and daily minimum and maximum temperature were computed and placed in columns to the left of the source data in calculation worksheets. Cumulative precipitation over the 24-hour day was also computed in columns to the left of the source data. Computed data were located on every twenty-fourth row of the computational columns.

To facilitate viewing of computed data, the Excel® FILTER function was used in the computational columns, with the filter for nonblank rows turned ON, thereby hiding all blank rows and allowing every twenty-fourth row to be easily seen. In addition, daily values were copied without blanks, with the FILTER function invoked, from the calculation worksheets to the summary worksheets listed in Table 6.1-3.

Table 6.1-3. Summary Worksheets with Computed Parameters of Daily Values for 1993 through 2004

Summary Worksheet Names	Units	Description
Daily MinTemp	degrees Celsius	Minimum daily temperature per day for 1993 through 2004. Minimum daily temperature, 2 m above ground.
Daily MaxTemp	degrees Celsius	Maximum daily temperature per day for 1993 through 2004. Maximum daily temperature, 2 m above ground.
AVGTEMP	degrees Celsius	Average daily temperature for 1993 through 2004.
Daily TtlPpt	millimeters	Total daily precipitation for 1993 through 2004 (YM Site 1 precipitation data from 1993 are not used).
AVG_WS	meters per second	Average daily horizontal wind speed for 1993 through 2004. Average daily horizontal wind speed 10 m above ground.
AVG_DewPt	degrees Celsius	Average dew-point temperature measured only at YM Site 1, only from 1993 through 1998. Dew-point temperature measured at 2 m above ground.
Avg_RH	percentage	Average daily relative humidity for 1993 through 2004 (YM Site 1 did not record relative humidity for 1993 through 1998). Average relative humidity, 2 m above ground (YM Site 1 did not record relative humidity for 1993 through 1998).
AVG_BP	millibars	Average daily barometric pressure for 1993 through 2004.

Source: Output DTN: SN0608WEATHER1.005.

6.1.3 Internal Checking

Data were internally checked as follows:

- Simple diagnostic charts were generated within the yearly worksheets to view the calculated daily averages and to ensure that no unreasonable data were used as inputs. From these charts, outlier points were identified and, if necessary, removed from the data set. Thus, nonphysical values (e.g., “negative” wind speeds or temperatures greater than 50°C) were not incorporated into computed averages, or into minimum or maximum values.

- Other than precipitation data, daily averages of minimum or maximum values were not derived or transmitted to summary worksheets if, within that single day, six or more “n/a” designators were recorded.

- Data were correctly transmitted from calculation worksheets to summary worksheets.

- Weather-station data were downloaded to the appropriate Excel® worksheets and workbooks.

- “9999” designators were replaced with “n/a” designators on summary worksheets.

- Entries for the 366th day are included, as appropriate.

6.1.4 Output Site-Specific Data Used for Present-Day Climate Conditions

Output DTN: SN0608WEATHER1.005 consists of six workbooks (Table 6.1-2) that contain values for daily minimum and maximum temperature and total precipitation, in addition to averages for temperature, relative humidity, barometric pressure, and wind speed. The provided data pertain to YM Sites 1, 2, 3, 6, and 9. The sixth workbook is precipitation and temperature data recorded at YM Site 8 for 2004 only. Temperature data are included with precipitation data. Computed daily values derived from hourly measurements are compiled in eight summary worksheets (Table 6.1-3); are listed by Julian day for years 1993 through 2004; and include site names, elevations, and universal transverse mercator (UTM) coordinates.

6.1.5 Salient Points of Precipitation, Precipitation Rate, Temperature, and Wind Speed Patterns Observed at Site-Specific Location

Infiltration is inherently tied to precipitation, precipitation rate, temperature, and (to a lesser extent) wind speed. These meteorological parameters are necessary inputs to an infiltration model and are therefore discussed further in Sections 6.1.5.1 and 6.1.5.2.

Other parameters, such as barometric pressure, dew point, pressure, and relative humidity, provide insights into yearly and daily conditions and cycles, but are not necessary inputs to infiltration modeling, and are not discussed further.

6.1.5.1 Precipitation

Total yearly precipitation at YM Sites 1, 2, 3, 6, and 9, recorded from 1993 through 2004, is plotted in Figure 6.1-1. Due to instrumentation problems, precipitation recorded at YM Site 1 during Julian days 34 through 62, 2004, was underestimated. For those 29 days, therefore, precipitation data recorded at YM Site 8 was used as surrogate data for YM Site 1. The rationale for this use of surrogate data is that YM Site 8 is only 12 m lower in elevation than YM Site 1, and 1.5 km south-southeast.

Total precipitation by year and station are listed in Table 6.1-4. Precipitation in the Yucca Mountain vicinity varies yearly and by location (Figure 6.1-1). Of the five sites, with the exception of 1993, YM Site 9 consistently had the least yearly precipitation throughout the 12-year period, and YM Site 6 generally had the highest yearly precipitation (with the exception of years 1998 and 2003, during which YM Site 3 recorded more precipitation). At all five sites, cumulative precipitation was highest in 1998.

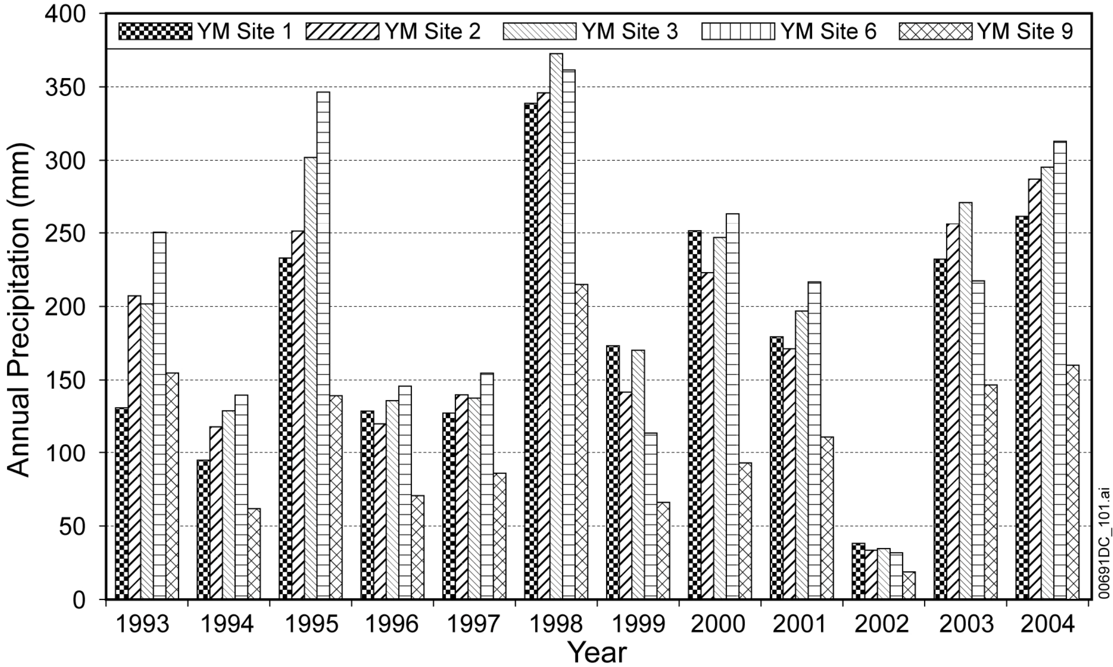
Average and median precipitation was calculated for the five sites over the 12-year time period (1993 through 2004) to determine whether a correlation exists between precipitation and elevation. Calculations confirm that a correlation does exist between average and median yearly precipitation and elevation (Figure 6.1-2).

Table 6.1-4. Yearly Precipitation at YM Sites 1, 2, 3, 6, and s9 (1993 through 2004)

	Precipitation (mm)				
Year	**YM Site 1 (1143 m)**	**YM Site 2 (1478 m)**	**YM Site 3 (1279 m)**	**YM Site 6 (1315 m)**	**YM Site 9 (838 m)**
1993	131.064	207.26	201.68	250.444	154.692
1994	94.742	118.11	129.036	139.7	61.722
1995	232.918	251.206	302.01	346.466	139.192
1996	128.778	120.142	135.89	145.796	70.612
1997	127.508	139.954	137.668	154.686	85.852
1998	338.836	345.948	372.618	361.442	214.884
1999	173.228	141.732	170.18	113.792	66.04
2000	251.46	223.012	246.888	263.652	92.964
2001	179.324	171.196	196.85	216.662	111.252
2002	38.1	33.528	34.544	31.75	18.796
2003	232.156	256.286	271.272	217.424	146.558
2004	261.874	287.274	295.402	312.928	160.017
Average	182.499	191.304	207.836	212.896	110.215
Median	176.276	189.228	199.265	217.043	102.108

Source: Output DTN: SN0608WEATHER1.005.

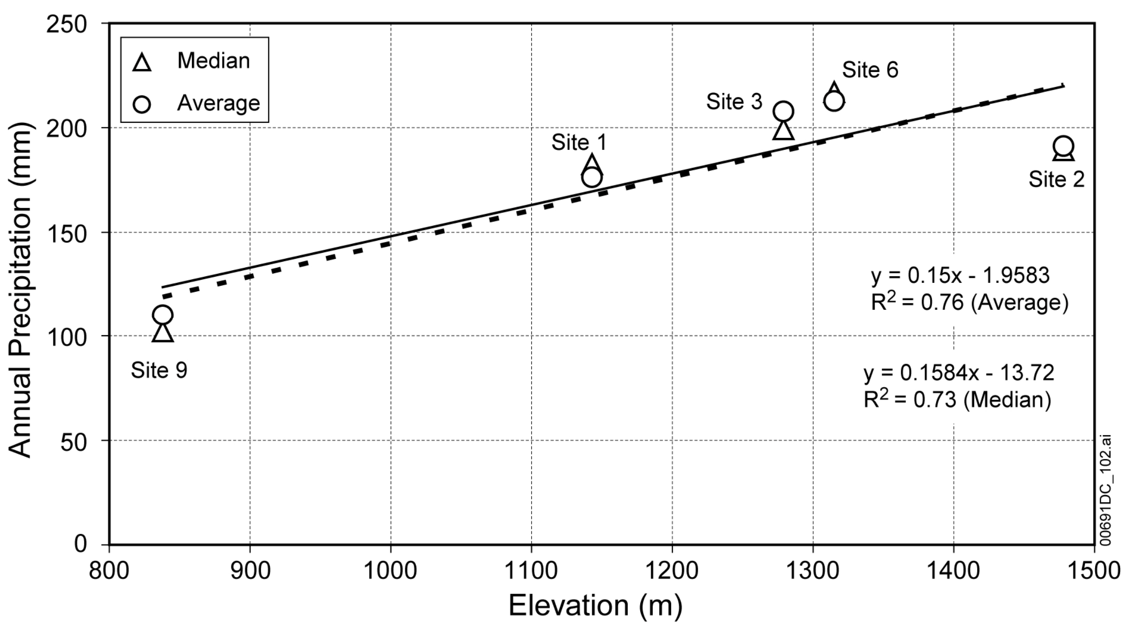
NOTE: Elevation for each station (in meters) is given below the station name.



Source: See Appendix F.

NOTE: YM Site 1 precipitation data for Julian days 34 through 62 (2004) was replaced with surrogate precipitation data from YM Site 8.

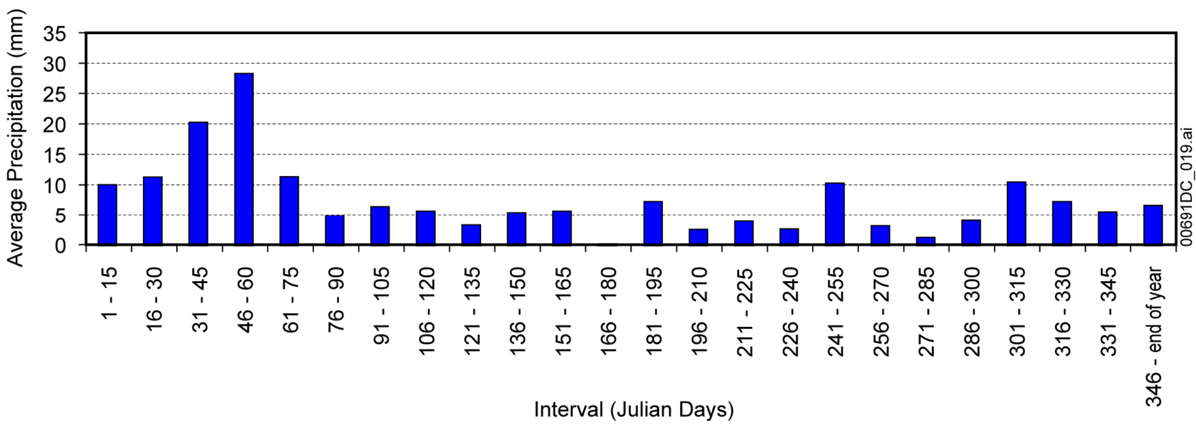
Figure 6.1-1. Yearly Precipitation at YM Sites 1, 2, 3, 6, and 9 (1993 through 2004)



Source: See Appendix F.

Figure 6.1-2. Average and Median Yearly Precipitation with Respect to Elevation for YM Sites 1, 2, 3, 6, and 9

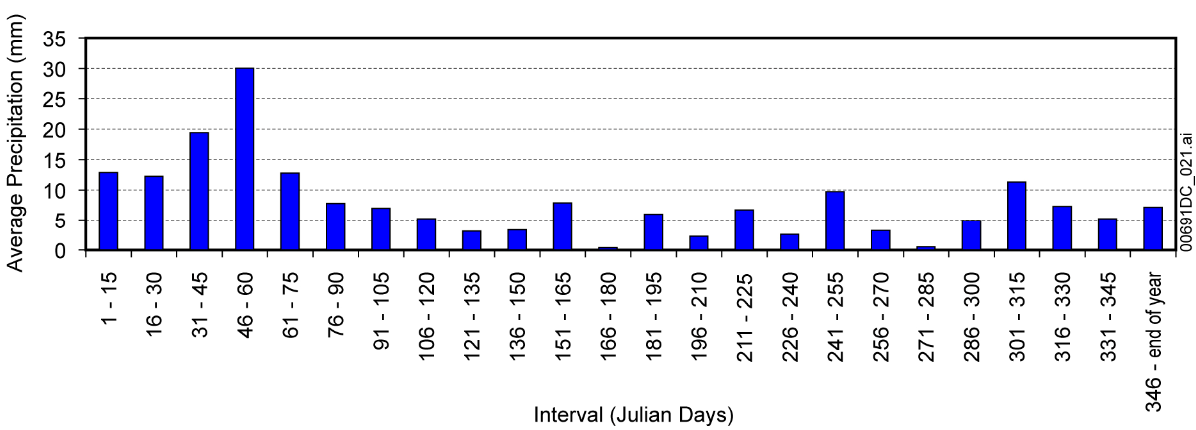
Bar plots of 15-day daily average precipitation values, calculated over the 12-year period, are provided as Figures 6.1-3, 6.1-4, 6.1-5, 6.1-6, and 6.1-7. Daily averages were grouped into 15-day intervals for plotting (e.g., the averages, including zero values, of all daily precipitation data for Julian days 1 through 15 were grouped, and then plotted as a single bar). The 15-day average plots reveal the general period during which precipitation falls at each site over the 12-year period (1993 through 2004). The selected interval size was determined to be small enough to show seasonal variability, yet large enough to minimize the influence of outlying data.



Source: Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

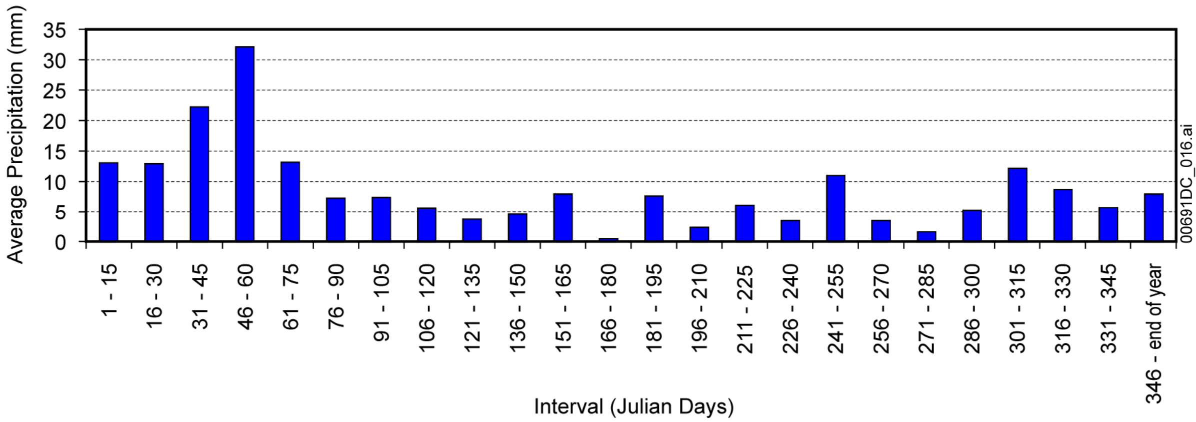
Figure 6.1-3. YM Site 1 Average 15-Day Interval Precipitation (1993 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

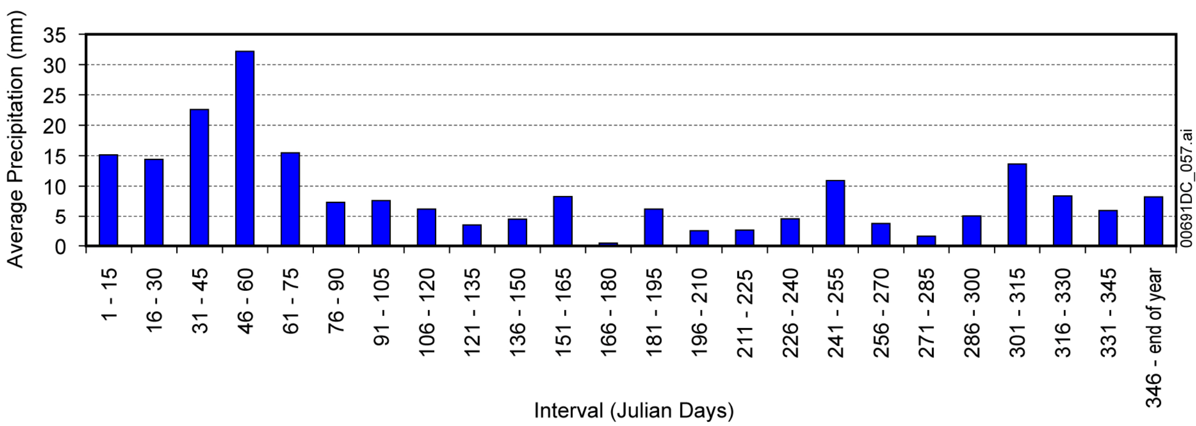
Figure 6.1-4. YM Site 2 Average 15-Day Interval Precipitation (1993 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

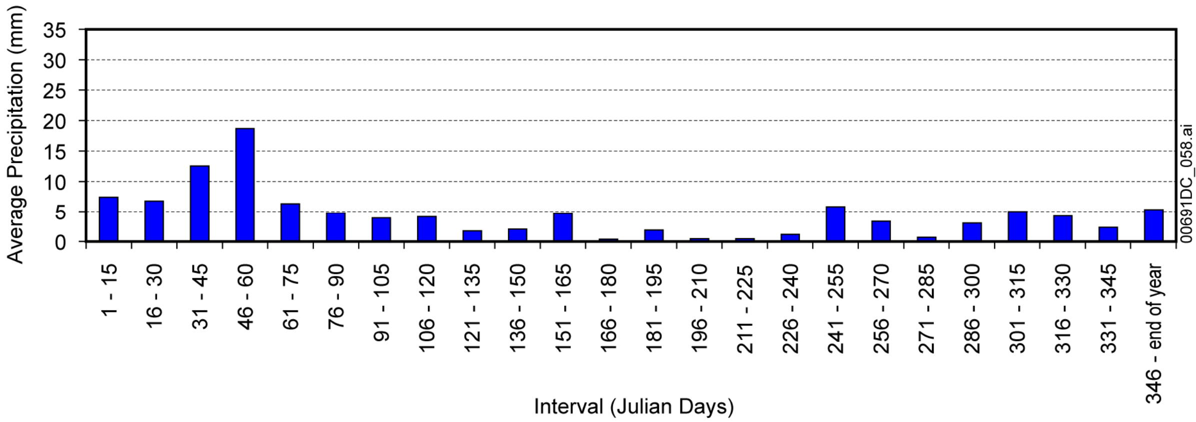
Figure 6.1-5. YM Site 3 Average 15-Day Interval Precipitation (1993 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.1-6. YM Site 6 Average 15-Day Interval Precipitation (1993 through 2004)

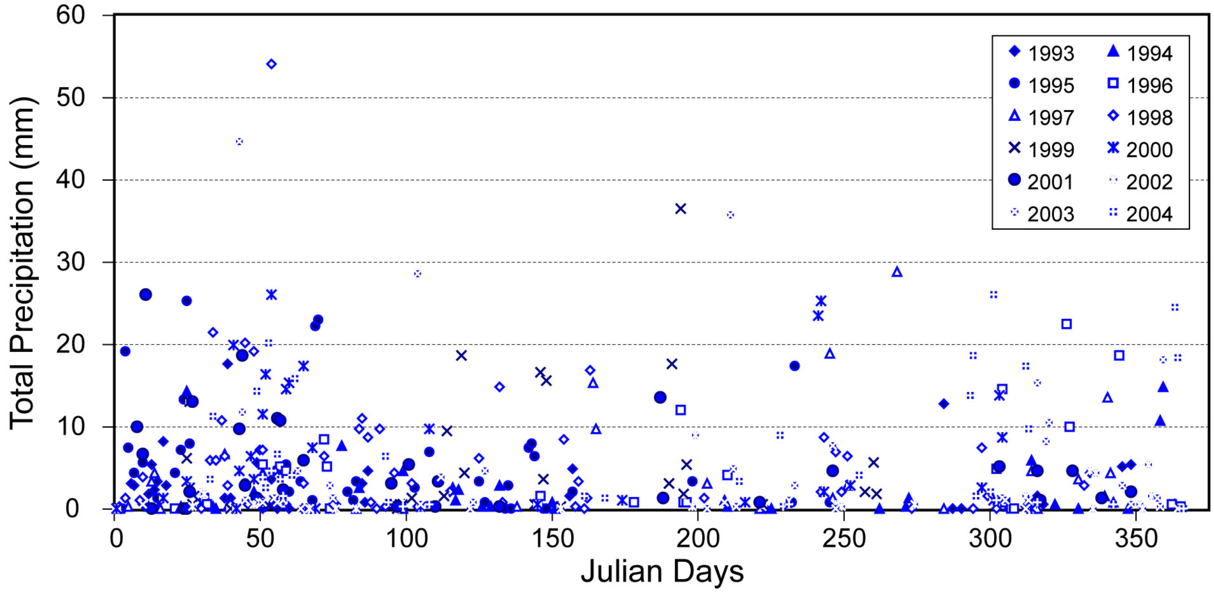


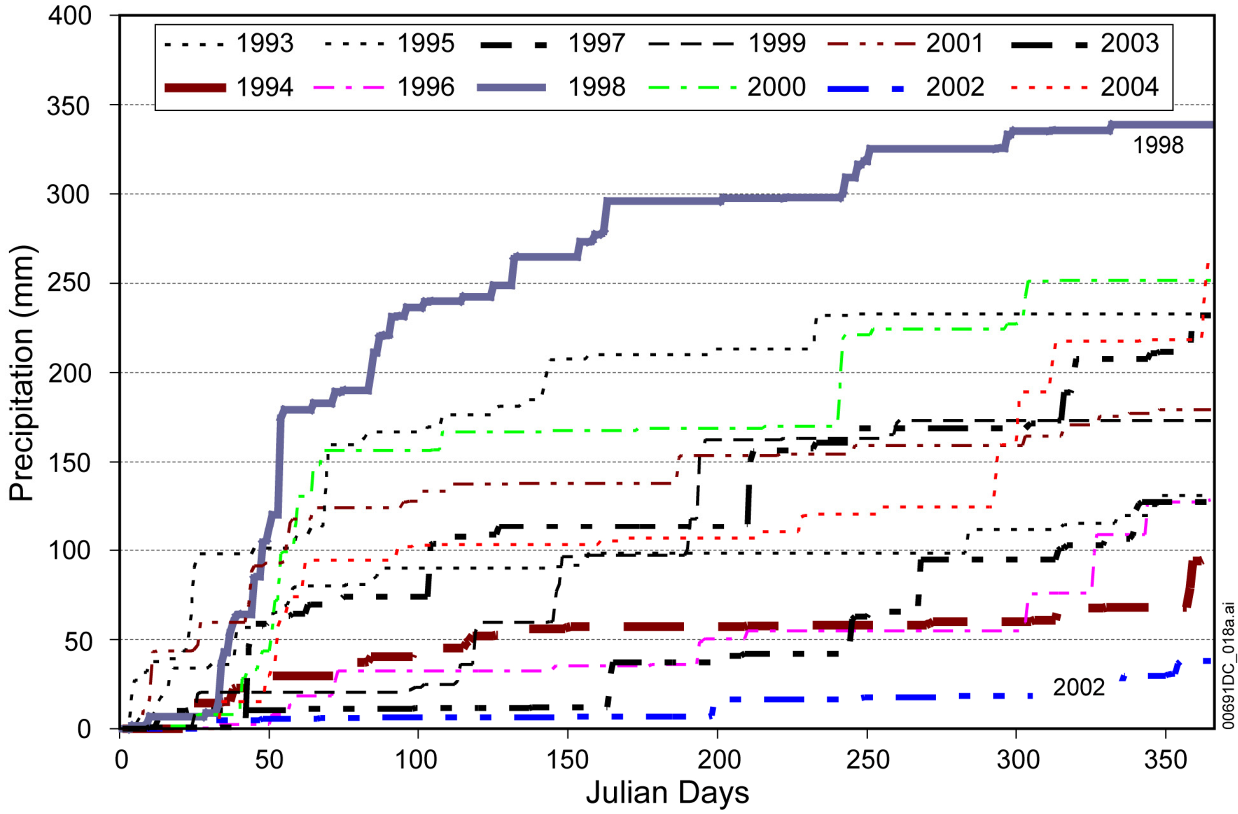
Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.1-7. YM Site 9 Average 15-Day Interval Precipitation (1993 through 2004)

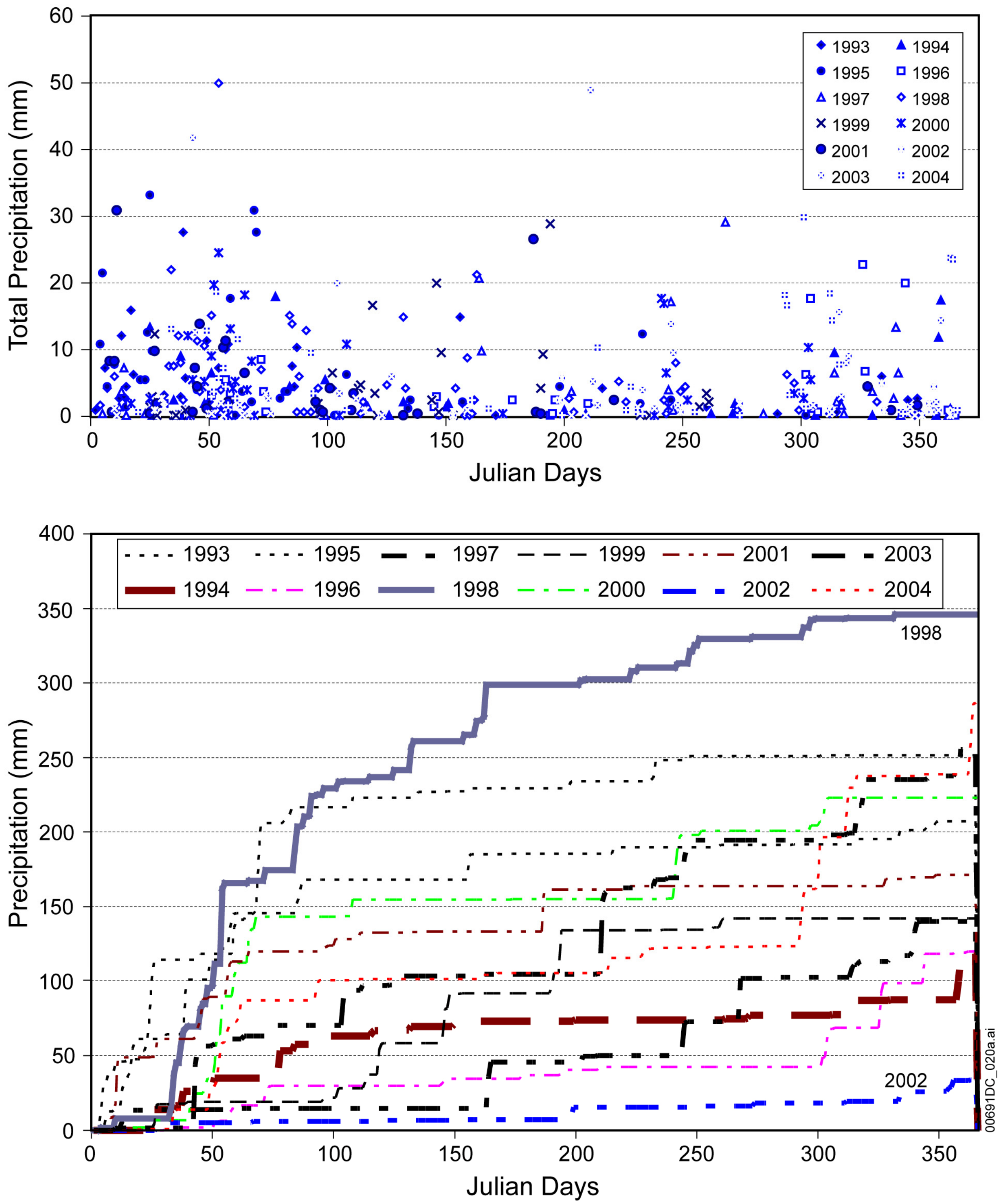
Scatter plots of daily precipitation recorded over the 12-year period (1993 through 2004) for each of the five sites are provided in Figures 6.1-8, 6.1-9, 6.1-10, 6.1-11, and 6.1-12 (upper graphs of these figures); cumulative daily precipitation by year is also shown for each site (lower graphs of the figures).





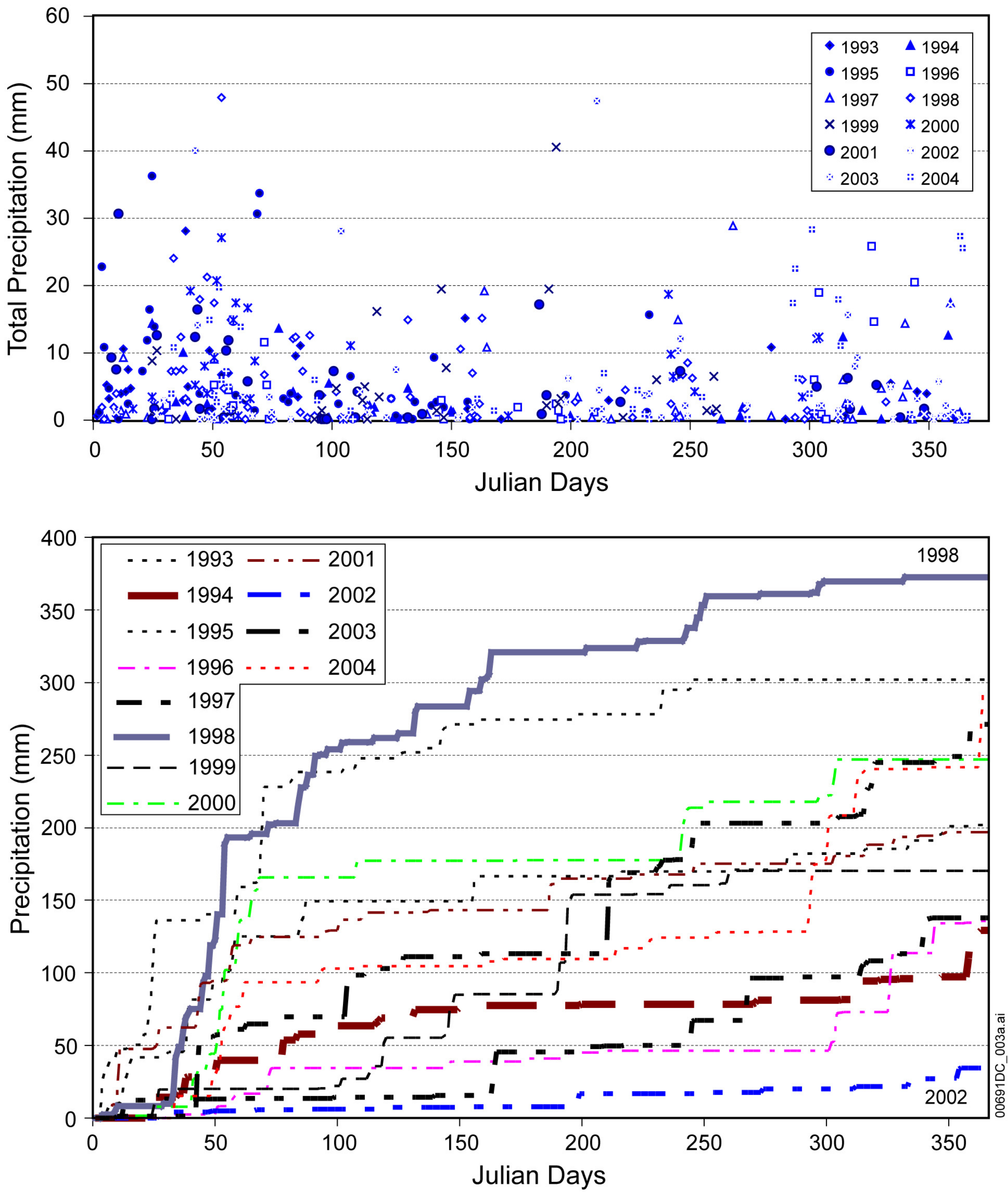
Source: See Appendix F.

Figure 6.1-8. YM Site 1 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation



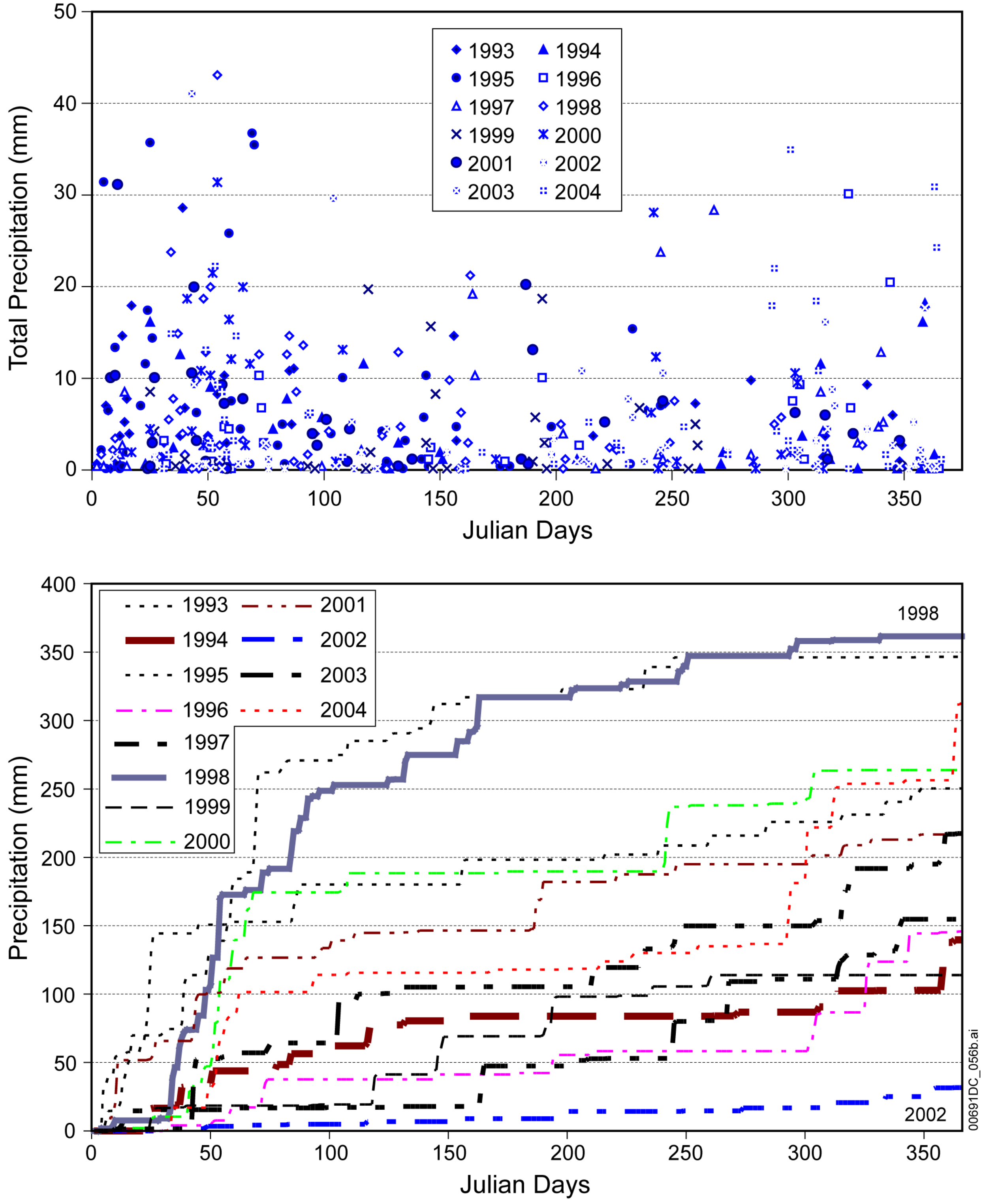
Source: See Appendix F.

Figure 6.1-9. YM Site 2 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation



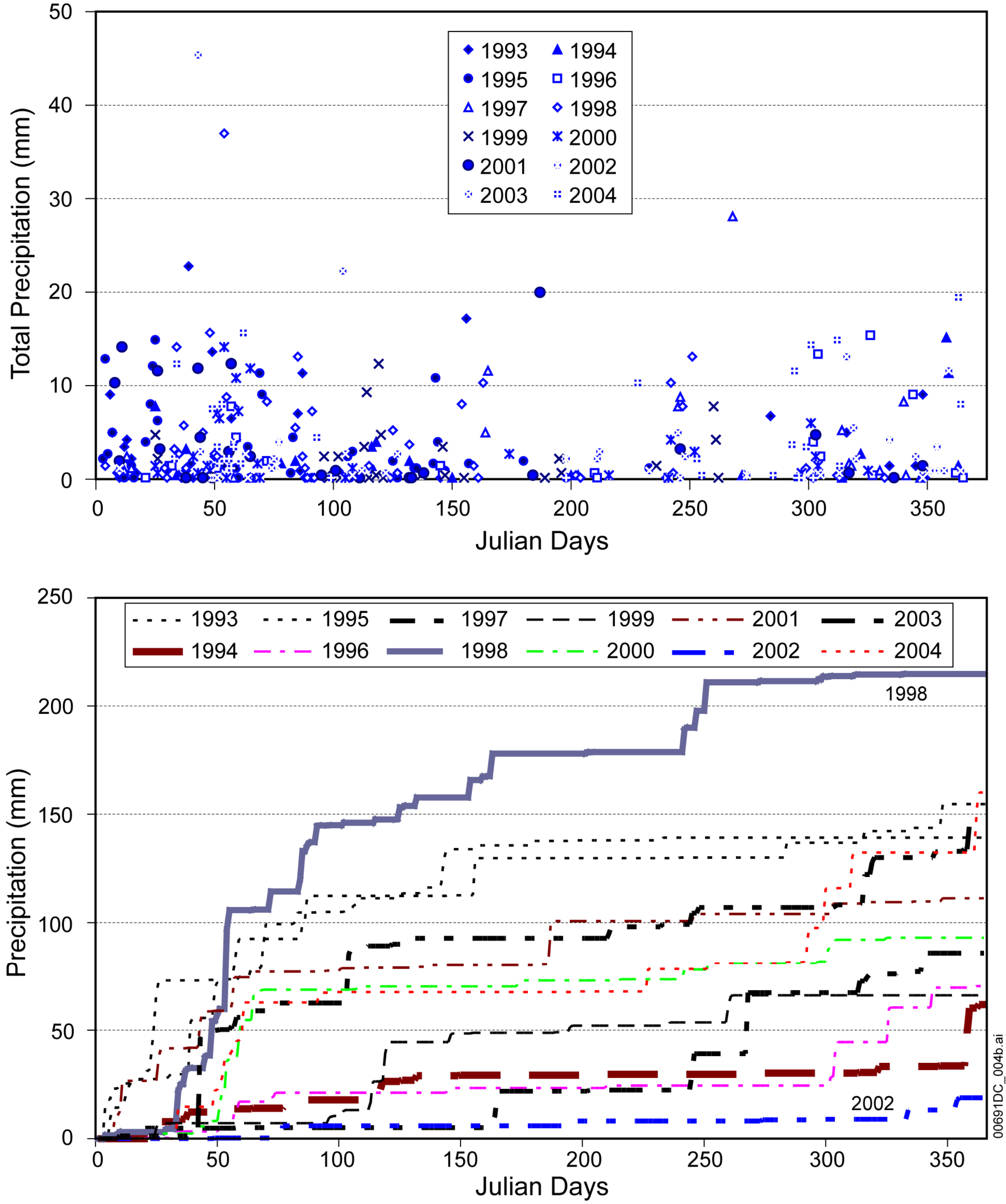
Source: See Appendix F.

Figure 6.1-10. YM Site 3 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation



Source: See Appendix F.

Figure 6.1-11. YM Site 6 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation



Source: See Appendix F.

Figure 6.1-12. YM Site 9 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation

The cumulative precipitation plots (Figures 6.1-8, 6.1-9, 6.1-10, 6.1-11, and 6.1-12) and the 15-day interval bar plots (Figures 6.1-3, 6.1-4, 6.1-5, 6.1-6, and 6.1-7) indicate that between 60% and 80% of the yearly precipitation primarily occurs during the late-winter to early-spring, between Julian day 25 and Julian day 160. The largest precipitation events occur between Julian days 31 through 60. These late-winter to early-spring events can last for several days, and are characterized by clusters of frequent and relatively small amounts of precipitation that occur sporadically.

During Julian days 160 through 260, when (generally speaking) days are hot and there are more daylight hours, precipitation tends to occur as large, isolated events. These events deliver relatively large volumes of water, and are separated by many days during which no precipitation occurs.

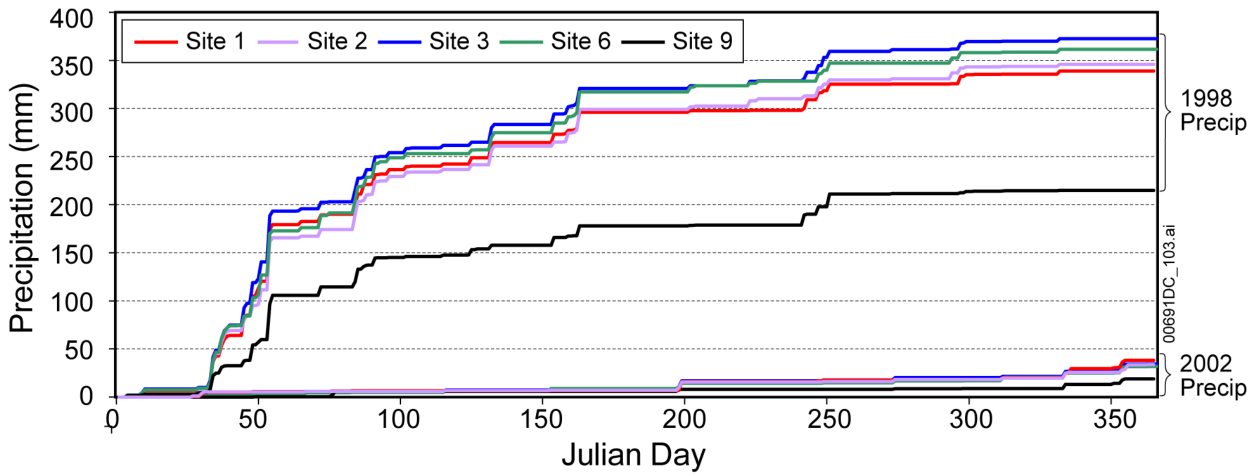
With respect to the time of year, each site follows similar precipitation trends during the 12-year period (1993 through 2004). The 15-day interval bar plots (Figures 6.1-3, 6.1-4, 6.1-5, 6.1-6, and 6.1-7) indicate that wet periods tend to be clustered between Julian days 1 through 75, with large precipitation "pulses" occurring between Julian days 31 through 60 at each site.

The least precipitation occurred during the late spring, between Julian day 166 and Julian day 180. This dry period was followed by an intermittent dry period, punctuated by relatively small precipitation pulses that (generally) ended around Julian day 300. Precipitation begins to increase around Julian day 301.

To determine whether any precipitation patterns or cycles exist between sites and years, cumulative precipitation for each site is plotted in Figure 6.1-13 for the wettest year (1998) and the driest year (2002). Additionally, 1995 precipitation for each site is plotted in Figure 6.1-14 (1995 was selected because cumulative precipitation during that year exhibited a large variability between the sites).

Over the 12-year period, the lowest cumulative precipitation is consistently recorded at YM Site 9, which is situated at the lowest elevation (Figure 6.1-14). During the late-winter to early-spring months, at least 50% less precipitation occurs at this location than at the higher-elevation sites (i.e., precipitation at YM Sites 1, 2, 3, and 6 is at least double).

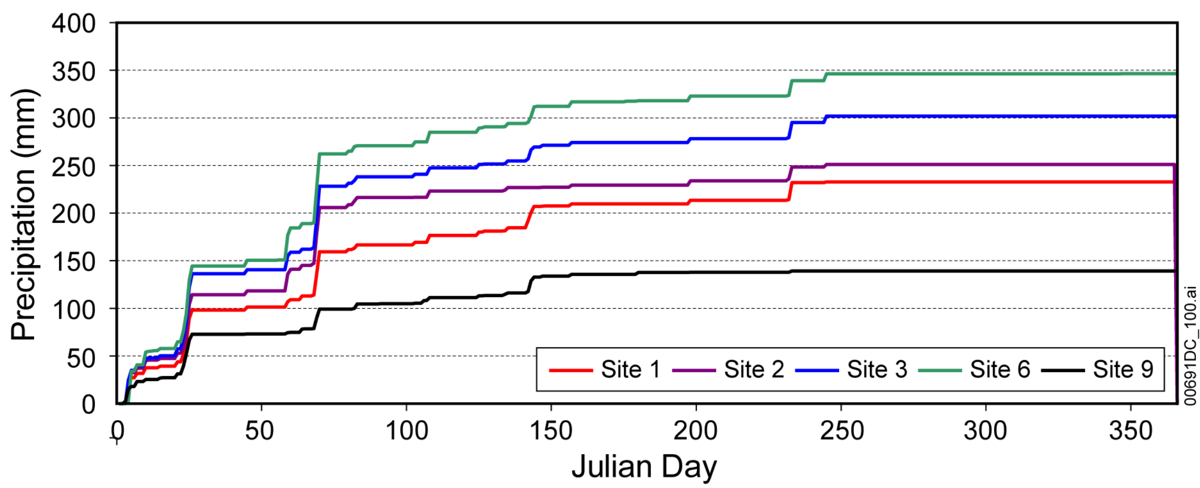
The large and isolated precipitation "pulses" that occur during the late summer or early fall are illustrated in the cumulative precipitation plots for 1998 and 2002, and for 1995 (Figures 6.1-13 and 6.1-14, respectively). During 1998, the precipitation events recorded at the higher-elevation sites tend to cluster together. The absence of late-winter/early-spring precipitation during 2002 renders that year a "drought" year.



Source: See Appendix F.

NOTE: Legend: The upper five lines represent 1998 readings, the lower five lines represent 2002 readings.

Figure 6.1-13. Cumulative Precipitation for YM Sites 1, 2, 3, 6, and 9 (1998 and 2002)

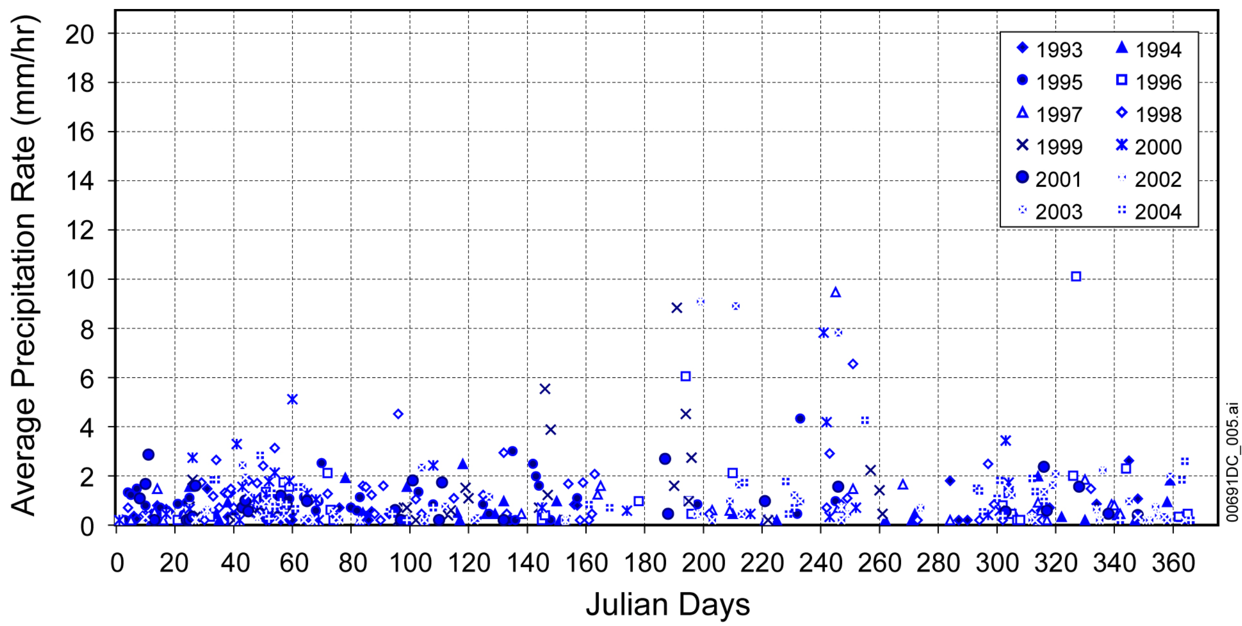


Source: See Appendix F.

Figure 6.1-14. Cumulative Precipitation for YM Sites 1, 2, 3, 6, and 9 (1995)

6.1.5.2 Precipitation Rate Data

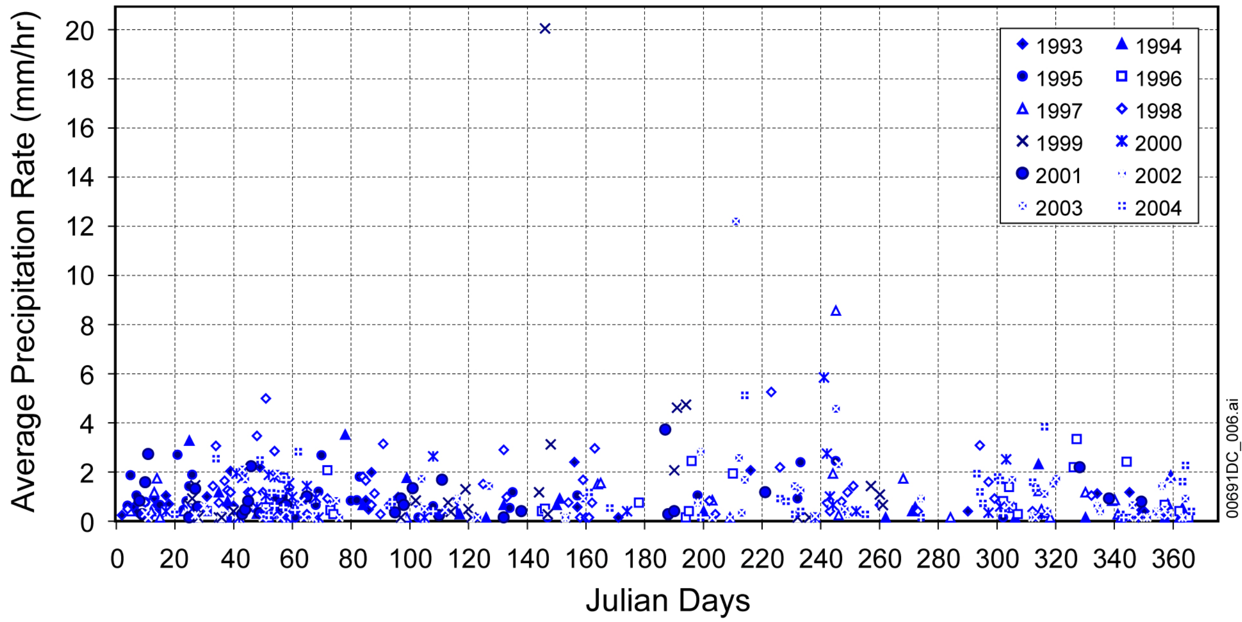
Precipitation data for YM Sites 1, 2, 3, 6, 8, and 9 are calculated by summing the precipitation recorded hourly during a 24-hour period (midnight to midnight), then dividing that sum by the number of hours during which precipitation was recorded for that day. The result is an hourly precipitation rate (mm/hr) for a precipitation event; precipitation occurring on consecutive days is treated as separate events. Because the rate (mm/hr) is calculated from hourly data, rather than directly measured, the data may slightly underestimate any directly measured rates. For example, if there is 1 mm of precipitation falling over a 30-minute period, it is recorded as falling during a 1-hour timeframe, resulting in a calculated precipitation rate that is half that of the real-time event. Rates have been calculated to illustrate precipitation rate patterns for an annual cycle over the 12-year period (1993 through 2004) (Figures 6.1-15, 6.1-16, 6.1-17, 6.1-18, 6.1-19). (Note that Site 1 precipitation data, for Julian days 34 through 62 of 2004, were deemed invalid. Therefore, Site 8 precipitation data were substituted as surrogate data for Site 1 during this period only.)



Source: See Appendix F.

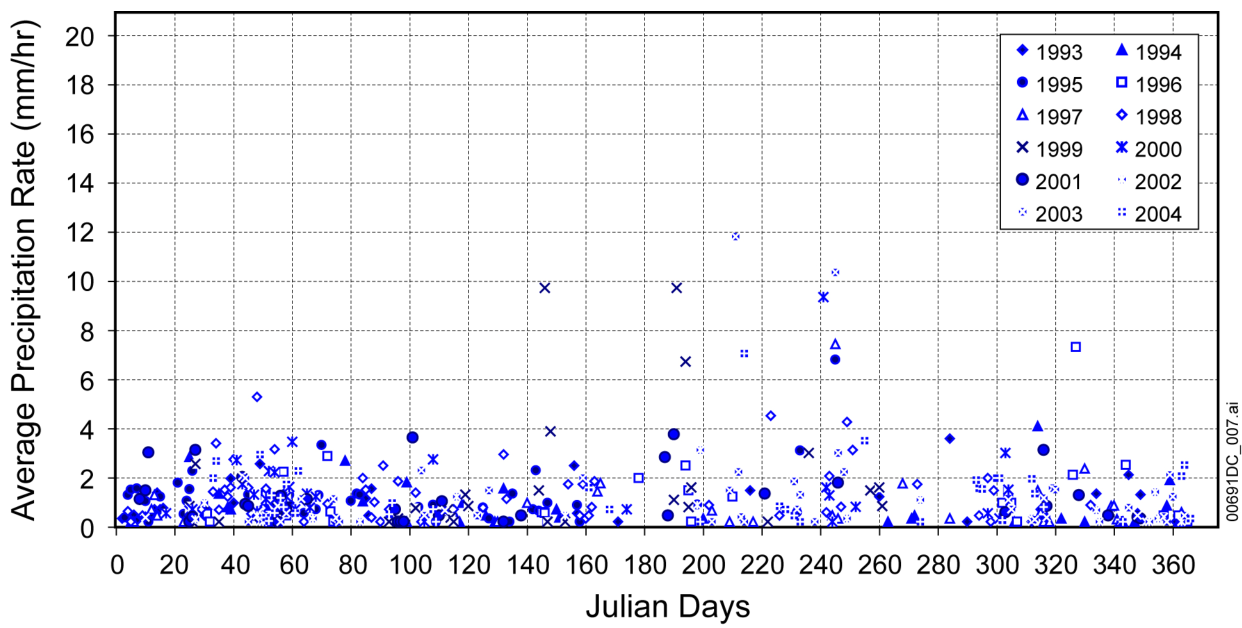
NOTE: YM Site 8 precipitation data for Julian days 34 through 62, 2004, were substituted for YM Site 1 data for that period, and are included in the YM Site 1 calculation of average precipitation rate.

Figure 6.1-15. Calculated Precipitation Rate for YM Site 1 (Julian days 1 through 365 [or 366])



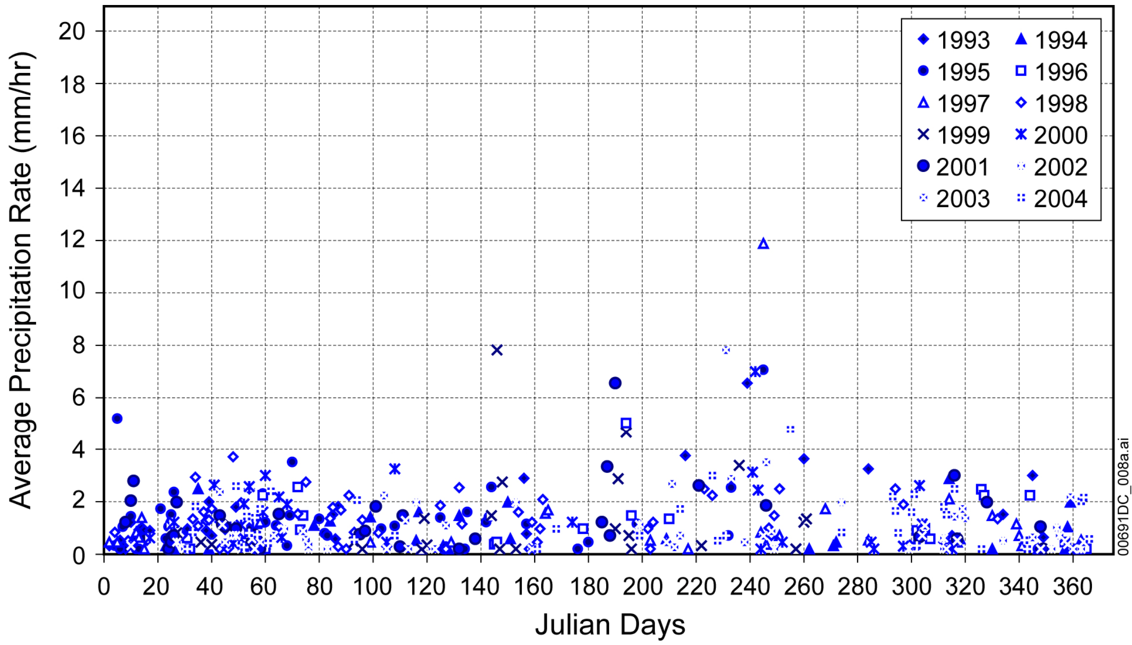
Source: See Appendix F.

Figure 6.1-16. Calculated Precipitation Rate for YM Site 2 (Julian days 1 through 365 [or 366])



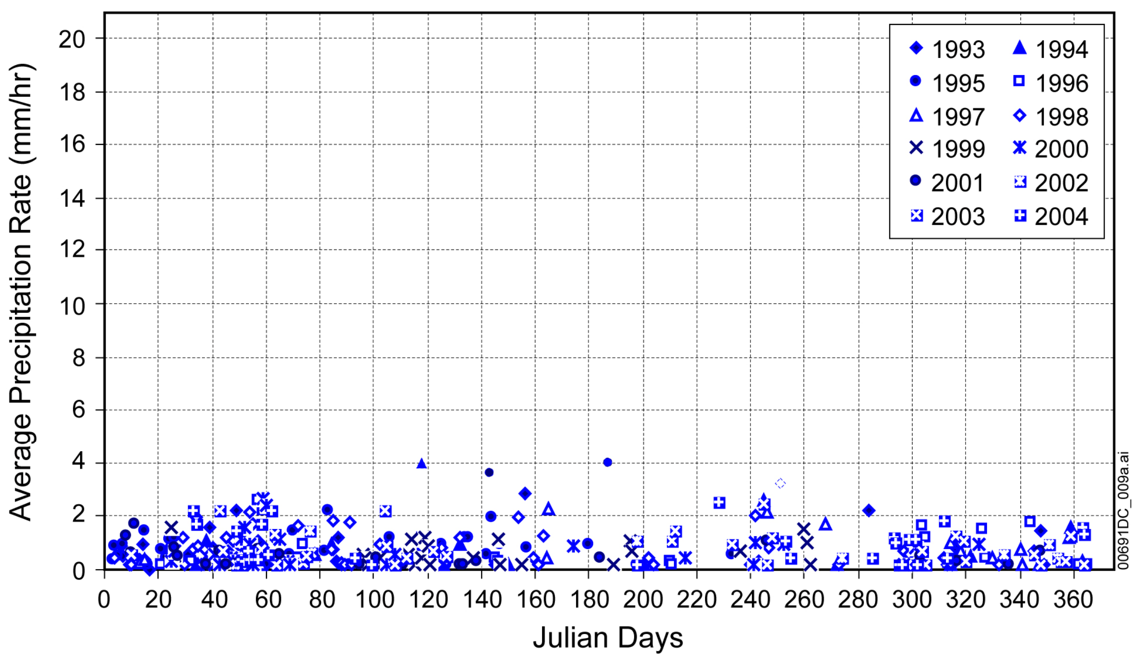
Source: See Appendix F.

Figure 6.1-17. Calculated Precipitation Rate for YM Site 3 (Julian days 1 through 365 [or 366])



Source: See Appendix F.

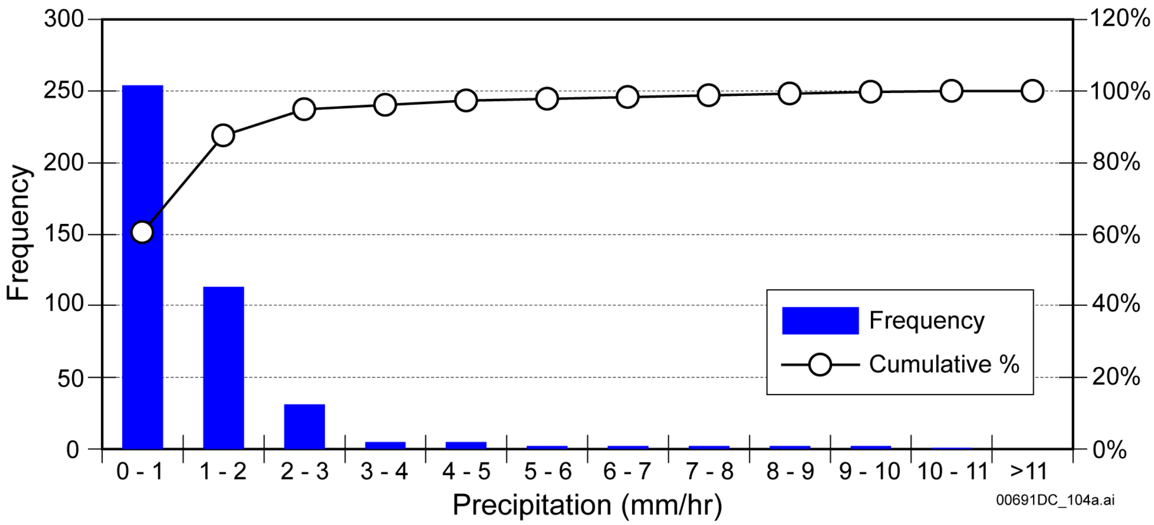
Figure 6.1-18. Calculated Precipitation Rate for YM Site 6 (Julian days 1 through 365 [or 366])



Source: See Appendix F.

Figure 6.1-19. Calculated Precipitation Rate for YM Site 9 (Julian days 1 through 365 [or 366])

Histograms of calculated precipitation rates for each site are provided as Figures 6.1-20, 6.1-21, 6.1-22, 6.1-23, and 6.1-24. The histograms only include rates for days during which there was a precipitation event; they do not show days when there is no precipitation. Each histogram is accompanied by a table that lists the cumulative distribution of daily precipitation rates and frequency (Tables 6.1-5, 6.1-6, 6.1-7, 6.1-8, and 6.1-9). The frequency for the total number of days in the 12-year period includes both the "dry" days and the "wet" days (Tables 6.1-6, 6.1-7, 6.1-8, 6.1-9, and 6.1-10). The right half of each table shows the calculated daily precipitation rate and frequency for (only) the set of days during which precipitation occurred.



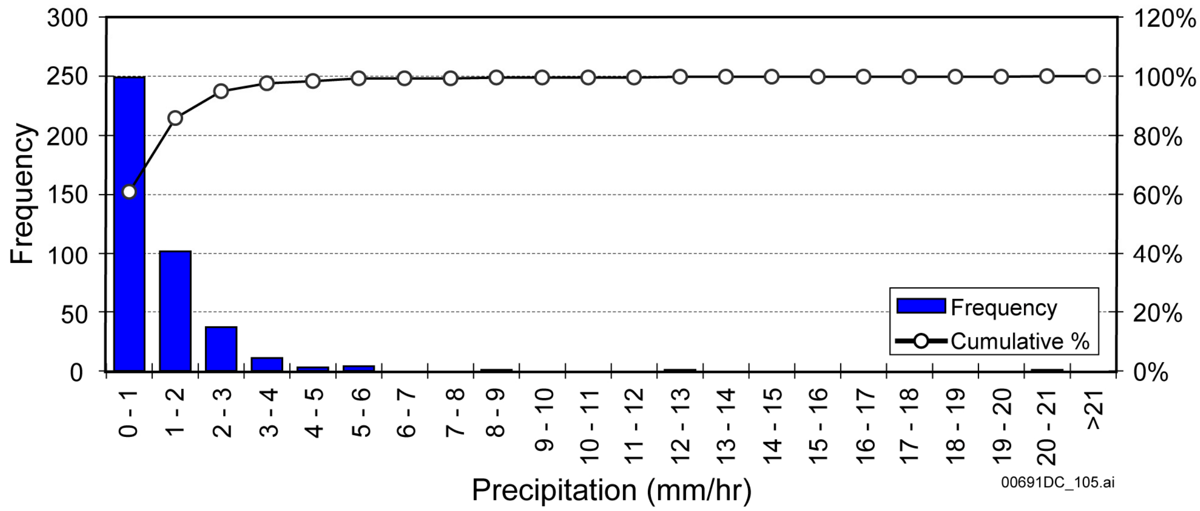
Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-20. YM Site 1 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-5. YM Site 1 Histogram Table for Precipitation Rates for Years 1993 through 2004

Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)			Calculated Daily Precipitation Rate and Frequency for "Wet" Days (ranked by frequency)		
Rate (mm/hr)	Frequency	Cumulative %	Rate (mm/hr)	Frequency	Cumulative %
0	3,964	90.44			
>0 to 1	254	96.24	>0 to 1	254	60.62
>1 to 2	113	98.81	>1 to 2	113	87.59
>2 to 3	31	99.52	>2 to 3	31	94.99
>3 to 4	5	99.63	>3 to 4	5	96.18
>4 to 5	5	99.75	>4 to 5	5	97.37
>5 to 6	2	99.79	>5 to 6	2	97.85
>6 to 7	2	99.84	>6 to 7	2	98.33
>7 to 8	2	99.89	>7 to 8	2	98.81
>8 to 9	2	99.93	>8 to 9	2	99.28
>9 to 10	2	99.98	>9 to 10	2	99.76
>10 to 11	1	100.00	>10 to 11	1	100.00



Source: See Appendix F.

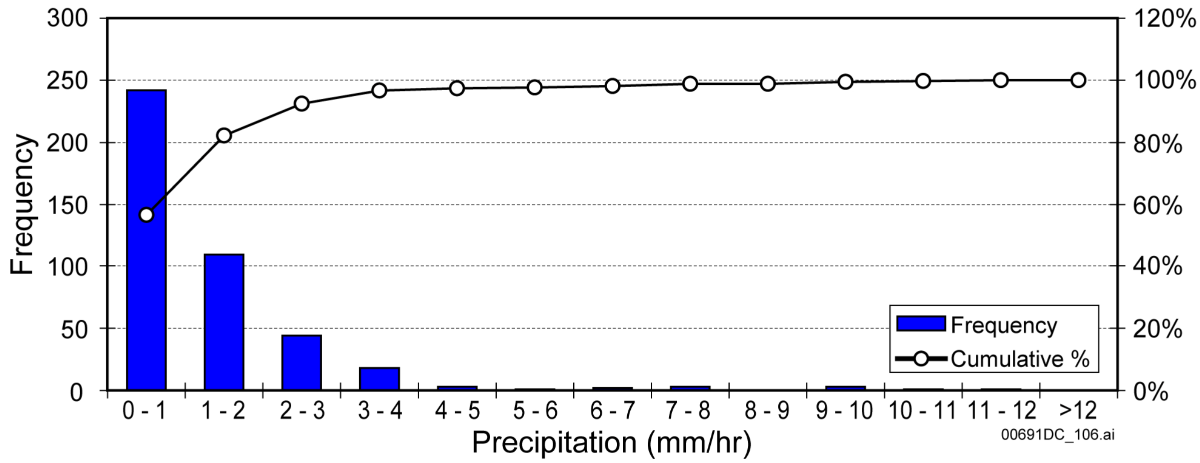
NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-21. YM Site 2 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-6. YM Site 2 Histogram Table for Precipitation Rates for Years 1993 through 2004

Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
0	3,974	90.67%
>0 to 1	249	96.35%
>1 to 2	102	98.68%
>2 to 3	37	99.52%
>3 to 4	11	99.77%
>4 to 5	3	99.84%
>5 to 6	4	99.93%
>6 to 8	0	99.93%
>8 to 9	1	99.95%
>9 to 12	0	99.95%
>12 to 13	1	99.98%
>13 to 20	0	99.98%
>20 to 21	1	100.00%

Calculated Daily Precipitation Rate and Frequency for “Wet” Days (ranked by frequency)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
>0 to 1	249	60.88%
>1 to 2	102	85.82%
>2 to 3	37	94.87%
>3 to 4	11	97.56%
>5 to 6	4	98.53%
>4 to 5	3	99.27%
>8 to 9	1	99.51%
>12 to 13	1	99.76%
>20 to 21	1	100.00%
>6 to 8	0	100.00%
>9 to 12	0	100.00%
>13 to 20	0	100.00%



Source: See Appendix F.

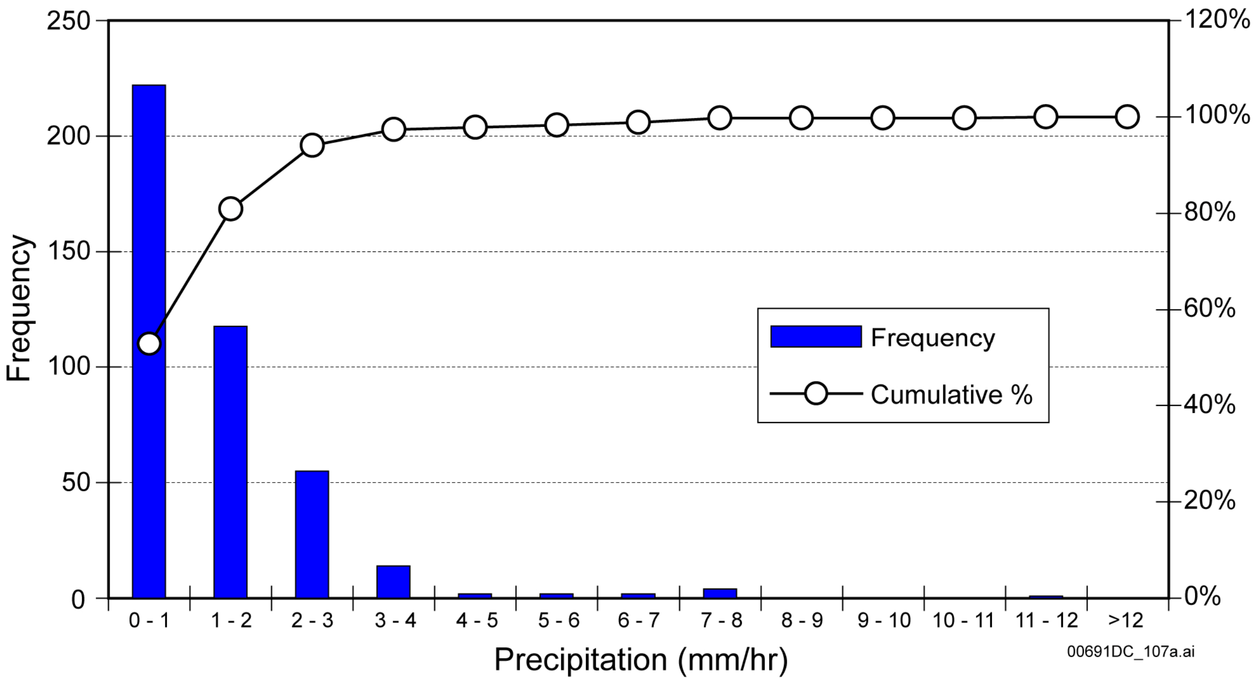
NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-22. YM Site 3 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-7. YM Site 3 Histogram Table for Precipitation Rates for Years 1993 through 2004

Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
0	3,956	90.26
>0 to 1	242	95.78
>1 to 2	109	98.27
>2 to 3	44	99.27
>3 to 4	18	99.68
>4 to 5	3	99.75
>5 to 6	1	99.77
>6 to 7	2	99.82
>7 to 8	3	99.89
>8 to 9	0	99.89
>9 to 10	3	99.95
>10 to 11	1	99.98
>11 to 12	1	100.00
>12	0	100.00

Calculated Daily Precipitation Rate and Frequency for "Wet" Days (ranked by frequency)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
>0 to 1	242	56.67
>1 to 2	109	82.20
>2 to 3	44	92.51
>3 to 4	18	96.72
>4 to 5	3	97.42
>7 to 8	3	98.13
>9 to 10	3	98.83
>6 to 7	2	99.30
>5 to 6	1	99.53
>10 to 11	1	99.77
>11 to 12	1	100.00
>8 to 9	0	100.00
>12	0	100.00



Source: See Appendix F.

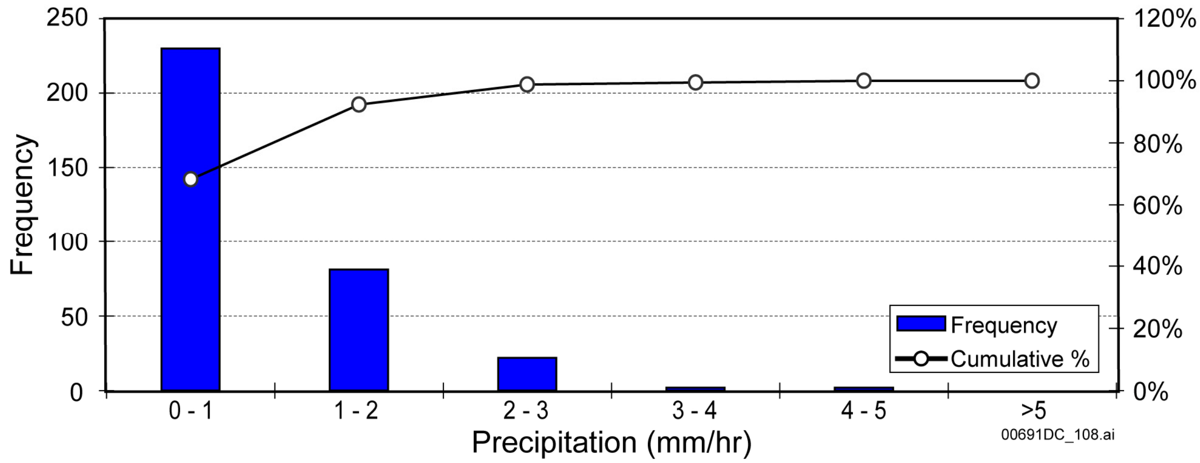
NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-23. YM Site 6 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-8. YM Site 6 Histogram Table for Precipitation Rates for Years 1993 through 2004

Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
0	3,963	90.42
>0 to 1	222	95.48
>1 to 2	118	98.17
>2 to 3	54	99.43
>3 to 4	14	99.75
>4 to 5	2	99.79
>5 to 6	2	99.84
>6 to 7	2	99.89
>7 to 8	4	99.98
>8 to 9	0	99.98
>9 to 10	0	99.98
>10 to 11	0	99.98
>11 to 12	1	100.00
>12	0	100.00

Calculated Daily Precipitation Rate and Frequency for "Wet" Days (ranked by frequency)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
0 to 1	222	52.86
1 to 2	118	80.95
2 to 3	55	94.05
3 to 4	14	97.38
7 to 8	4	97.86
4 to 5	2	98.33
5 to 6	2	98.81
6 to 7	2	99.76
11 to 12	1	100.00
8 to 9	0	100.00
9 to 10	0	100.00
10 to 11	0	100.00
>12	0	100.00



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-24. YM Site 9 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-9. YM Site 9 Histogram Table for Precipitation Rates for Years 1993 through 2004

Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
0	4,045	92.29
>0 to 1	231	97.56
>1 to 2	81	99.41
>2 to 3	22	99.91
>3 to 4	2	99.95
>4 to 5	2	100.00
>5	0	100.00

Calculated Daily Precipitation Rate and Frequency for "Wet" Days (ranked by frequency)		
Rate (mm/hr)	**Frequency**	**Cumulative %**
>0 to 1	231	68.34
>1 to 2	81	92.31
>2 to 3	22	98.82
>3 to 4	2	99.41
>4 to 5	2	100.00
>5	0	100.00

Numerous low precipitation-rate events (below 3 mm/hr) appear to cluster together (Figures 6.1-20, 6.1-21, 6.1-22, 6.1-23, and 6.1-24). These events tended to occur during late winter to early spring (Julian days 20 through 80); early spring to mid-spring (Julian days 90 through 130); and late fall and early winter (Julian days 290 through 320, and 340 through 366).

Low precipitation-rate events are the most numerous. Precipitation rates between 3 and 5 mm/hr tended to occur in mid-summer through early fall (Julian days 190 through 260), and tended to be isolated, with other low-precipitation-rate events occurring just before and after. Relatively large precipitation events (greater than 5 mm/hr) tended to be isolated and infrequent, and generally occurred in mid-summer through early fall (Julian days 190 through 260). YM Site 9 (as noted earlier, the lowest-elevation site of the five sites) received the least precipitation, and experienced very few precipitation events that generated more than 3 mm/hr (and none that generated more than 5 mm/hr) during the 12-year period.

The hourly precipitation rates (Tables 6.1-6 through 6.1-10) indicate that, over the 12-year period, no precipitation was recorded on approximately 90% of the days at the five sites. YM Site 9 had the largest frequency of "dry" days (92%); the plotted percent of "dry" days for YM Sites 1, 2, 3, and 6 are clustered near the 90% level.

At YM Sites 1, 2, 3, and 6, approximately 53% to 57% of the "wet" days had a calculated precipitation rate of >0 to 1 mm/hr. For YM Site 9, this rate occurred approximately 68% of the time. These rates are typical of light-rainfall events that occur in the desert environment.

The second-most-frequent precipitation rate at the five sites is the >1 to 2 mm/hr rate, and occurred approximately half as often as the >0 to 1 mm/hr rate. Precipitation rates above 4 mm/hr constitute less than 2% of the precipitation events. Isolated precipitation rates above 8 mm/hr occur only at YM Sites 1, 2, 3, and 6 in mid-summer to early fall, and represent approximately 1% to 2% of the precipitation events.

The largest precipitation rate, approximately 20 mm/hr, was an isolated event that occurred at YM Site 2 on Julian day 146 , 1999.

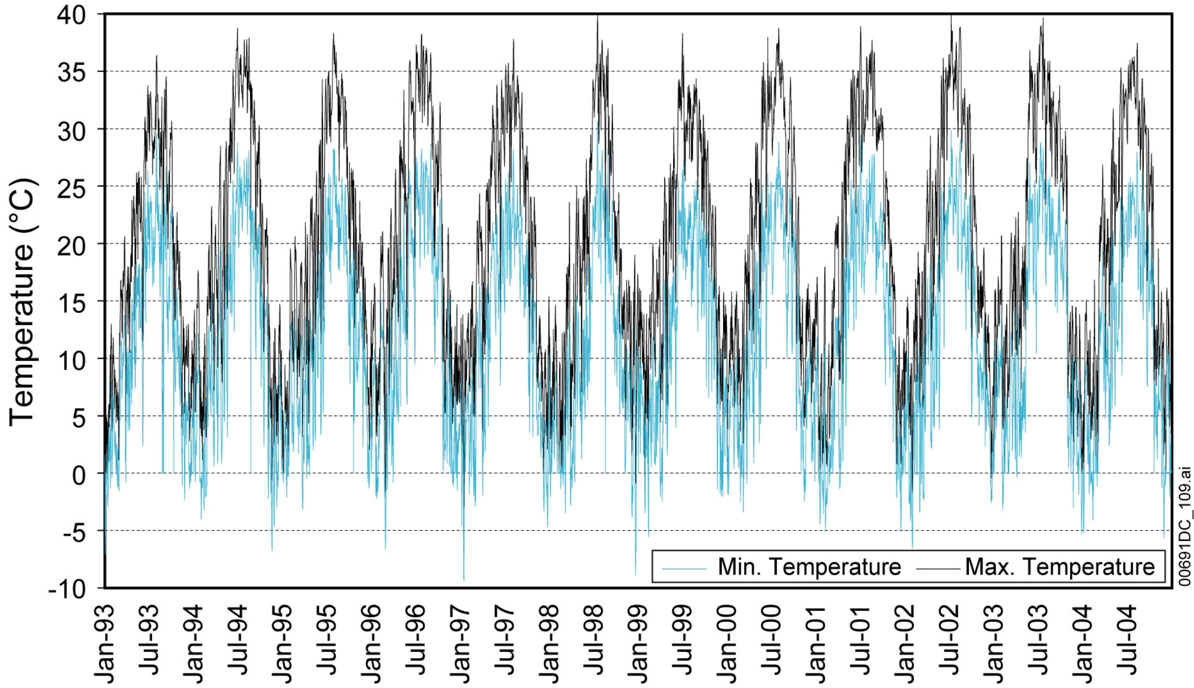
6.1.5.3 Temperature

When plotted over a year, temperatures follow a periodic cycle. Temperature highs and lows, and the slope between these extremes, appear to occur at approximately the same time during each 365-day cycle. An example of the cyclical nature of temperature is seen in the plot of daily minimum and maximum temperatures recorded at YM Site 2 over the 12-year period given in Figure 6.1-25.

Patterns or trends of a 365- (366-) day-cycle average-minimum and average-maximum daily temperature, over the 12-year period for YM Sites 1, 2, 3, 6, and 9, are shown in Figures 6.1-26 and 6.1-27.

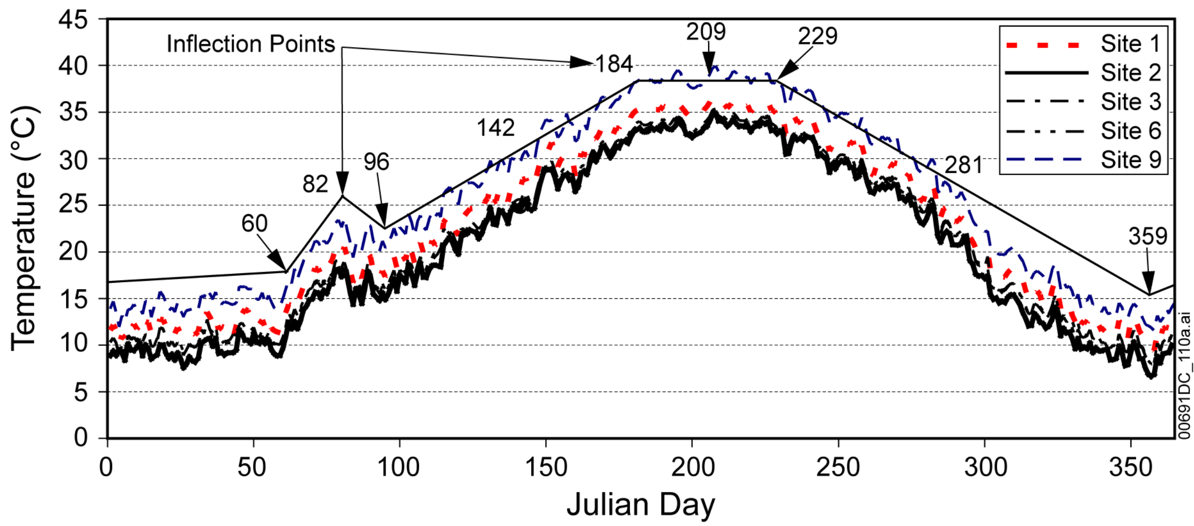
Figures 6.1-26 and 6.1-27 present temperature inflection points (points determined by drawing a line connecting, in this case, relative maximum points along the temperature curves; an inflection point exists wherever two such lines intersect). These inflection points are indicative of season transitions. Many of the points coincide with a few seasonal solstice or equinox days. Temperature inflection points occurred around:

- Julian days 59 and 60
- Julian days 81 and 82 (the vernal equinox)
- Julian days 95 and 96
- Julian days 189 and 190
- Julian day 208 or 209
- Julian day 229
- Julian days 355 to 357 (the winter solstice).



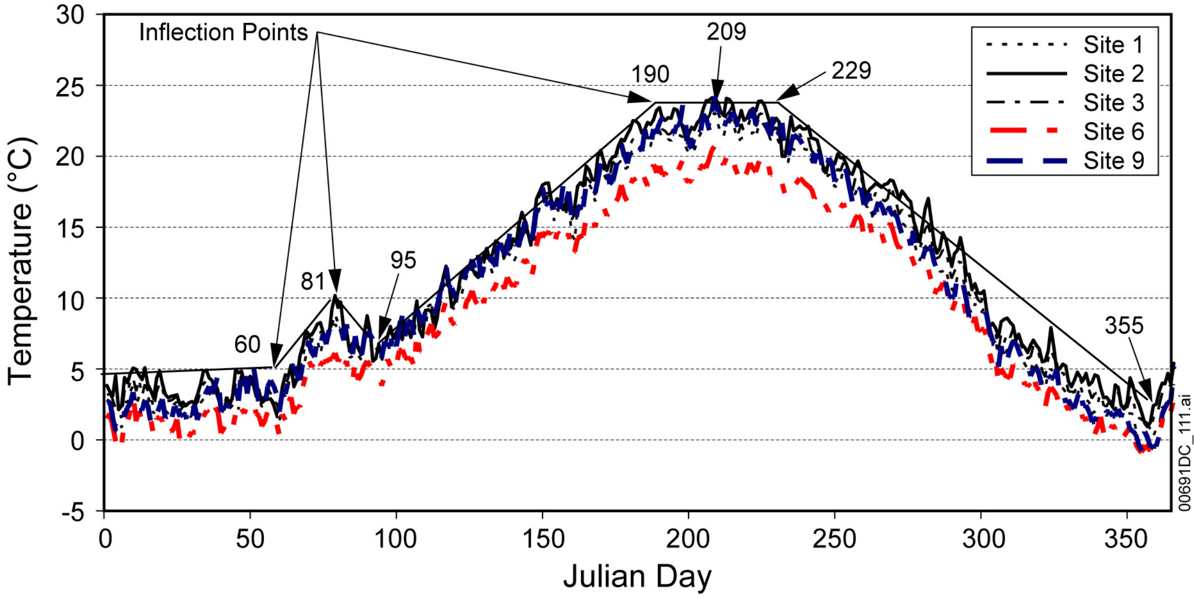
Source: See Appendix F.

Figure 6.1-25. Minimum and Maximum Daily Temperatures Recorded at YM Site 2 (1993 to 2004)



Source: See Appendix F.

Figure 6.1-26. Daily Maximum Temperatures Averaged over 1993 through 2004



Source: See Appendix F.

Figure 6.1-27. Daily Minimum Temperatures Averaged over 1993 through 2004

Throughout a 365- (366-) day period, there are trends in the minimum and maximum temperature curves at each site.

Temperature patterns and plateaus, and the locations of inflection points, are summarized as follows:

- On Julian day 59 or 60, both minimum and maximum temperatures transition from a relatively steady and narrow oscillatory period, to a period during which daily minimum and maximum temperatures start to increase rapidly. This higher-temperature transition period lasts for approximately 20 days, terminating around Julian day 80 or 81.

- For a brief (15-day) period beginning around Julian day 80 or 81 (the vernal equinox), temperatures transition to a phase during which they remain relatively constant, or rapidly decline. This period ends around Julian day 95 or 96.

- Around Julian day 95 or 96, both minimum and maximum temperatures transition into a relatively long period during which they steadily rise. This steady rise lasts for approximately 94 or 95 days, and ends around Julian day 189 or 190.

- Temperature values plateau between Julian day 189 or 190 and Julian day 228 or 229. During this period, daily minimum and maximum temperatures generally do not vary by more than a few degrees, and an annual temperature maximum occurs around Julian day 208 or 209. This high-temperature plateau persists for approximately 40 days.

- Around Julian day 229, plus or minus a day or two, daily temperature minimum and maximum values transition to a period during which temperatures begin to steadily decline. This declining trend continues for approximately 126 days, until approximately the period between Julian days 355 and 357 (the winter solstice). On or about Julian day 355 (the winter solstice), temperatures reach their lowest point in the 365- (366-) day cycle.

- After Julian day 355, plus or minus a day or two, temperatures transition to a phase during which they oscillate within a narrow band for approximately 70 days. This period is called the low-temperature plateau. The low-temperature plateau period ends around Julian day 59 or 60.

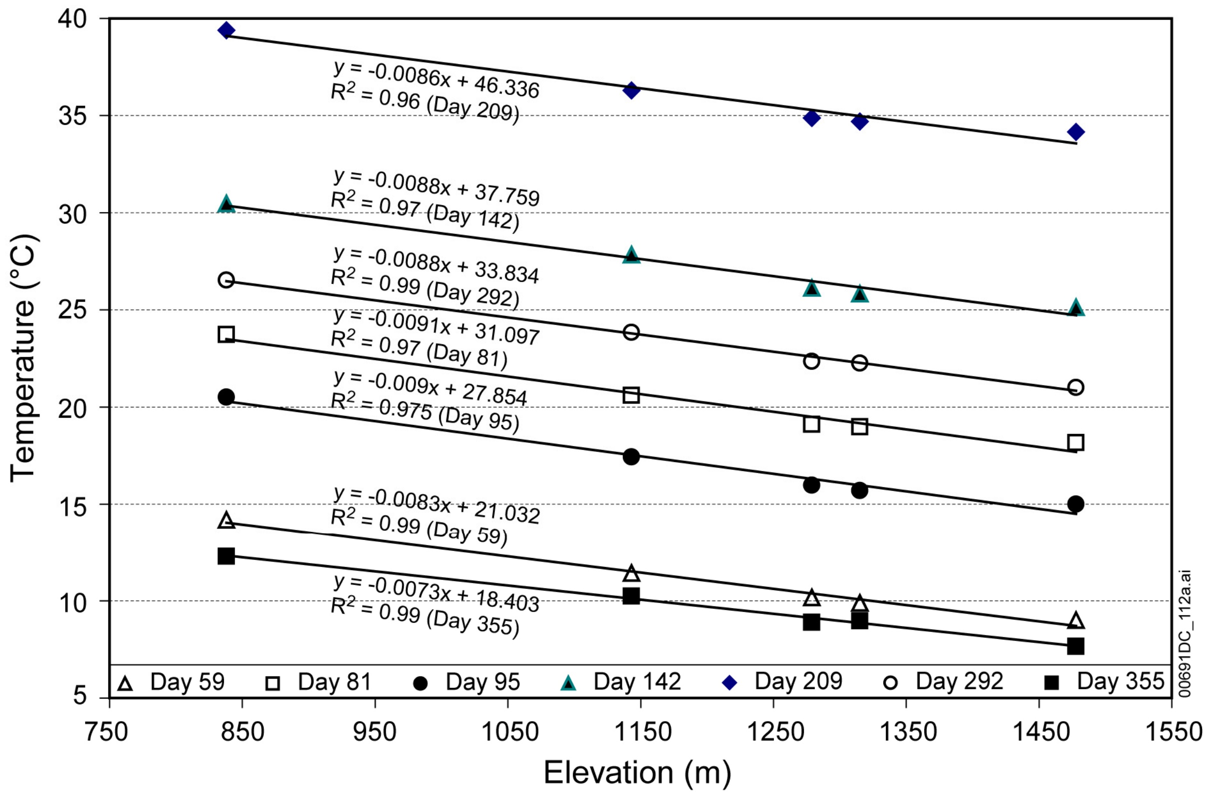
Generally, atmospheric ambient temperature is expected to decrease with elevation due to the natural lapse rate (i.e., because YM Site 2 is highest in elevation [of the five sites], it is expected to have the lowest temperatures throughout the year; conversely, because YM Site 9 is at the lowest elevation, it is expected to have the highest temperatures). Examination of the minimum and maximum temperature curves for the five sites indicates that this is not necessarily the case. Generally, temperature decreases with higher elevations, particularly in the daytime for the maximum temperatures. Nighttime minimum temperatures vary considerably due to cold air drainage through sites in the lower elevations, which typically results in lower temperatures occurring at lower elevations. This is true throughout the year.

YM Site 9 tends to have the lowest temperatures of the five YM sites analyzed throughout the year. This is due to nighttime cooling resulting in cold air drainage flow to lower elevations. Conversely, and in part due to the same phenomena, YM Site 2 tends to have the highest minimum temperature during the hottest period of the year (Julian days 190 through 229). With a few exceptions, YM Site 2 has the highest average minimum temperature throughout the 365- (366-) day cycle (less nighttime drainage influences). This includes days during which temperatures drop to their lowest point, on Julian days 355 to 357, then increase slightly and transition into the low-temperature plateau phase.

YM Site 6, second highest in elevation, generally has the lowest average minimum temperature throughout most of the 365- (366-) day cycle. During the low-temperature plateau (approximately Julian day 355 through Julian day 60), the lowest average minimum temperature alternates between YM Site 9 and other sites, predominately YM Site 6.

Plotted minimum and maximum temperatures, with respect to station elevation, are shown in Figures 6.1-28 and 6.1-29. The selected temperatures include some of the previously described inflection-point days, the midpoint (Julian day 142) of the rising temperature period (approximately 95 days), and the midpoint (Julian day 281) of the declining temperature period (approximately 126 days).

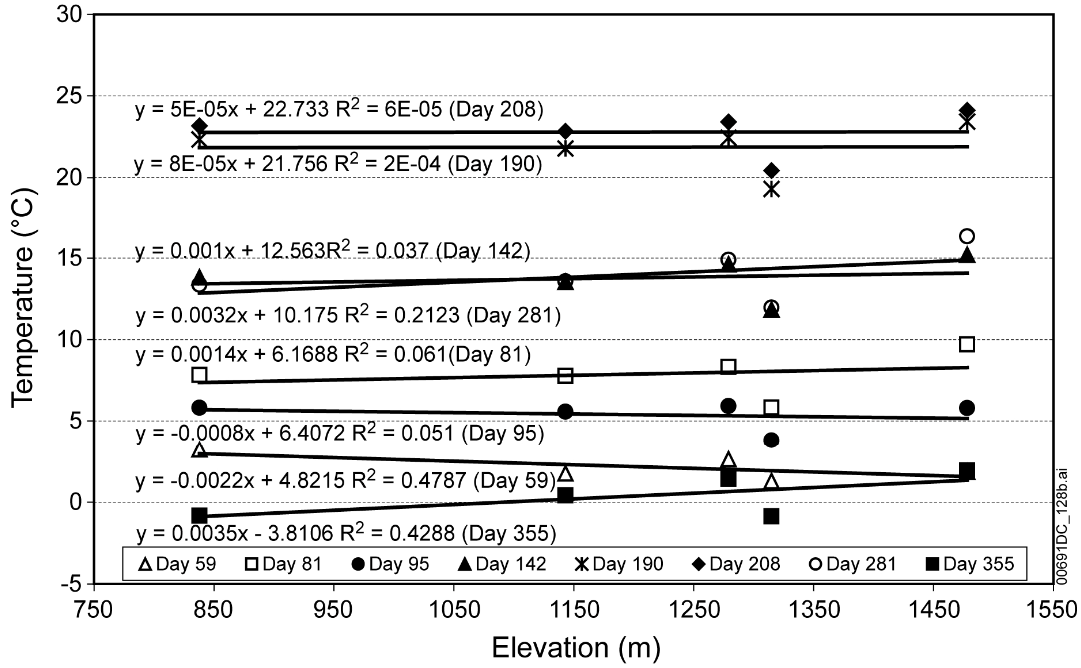
Linear regression of the average maximum daily temperatures at these inflections points indicates that a strong correlation exists between temperature maximum and elevation. Linear regression indicates that there is no correlation between daily temperature minimum and elevation.



Source: See Appendix F.

NOTE: The five YM Sites are arranged from lowest to highest elevation, i.e., Site 9, Site 1, Site 3, Site 6, and Site 2, respectively.

Figure 6.1-28. Average Maximum Temperature (1993 through 2004) at Temperature Inflection-Point Days and the Midpoint of the Spring and Fall Temperature Slopes for YM Sites 1, 2, 3, 6, and 9



Source: See Appendix F.

NOTE: The five YM Sites are arranged from lowest to highest elevation, i.e., Site 9, Site 1, Site 3, Site 6, and Site 2, respectively.

Figure 6.1-29. Average Minimum Temperature (1993 through 2004) at Temperature Inflection-Point Days and the Midpoint of the Temperature Slope Days for the Five YM Sites

6.1.5.4 Precipitation–Temperature Relationship

A discussion of the temperature–precipitation relationship for the wettest year can facilitate an understanding of the relationship between precipitation and infiltration. Plotted temperature profiles concurrent with precipitation events for 1998, the wettest year in the 12-year period, are shown in Figures 6.1-30 through 6.1-47. The plotted days represent large precipitation clusters for the year. Additional information (including temperature–precipitation overlay plots for each precipitation day in 1998, and several days before and after 1998) is provided in Appendix D.

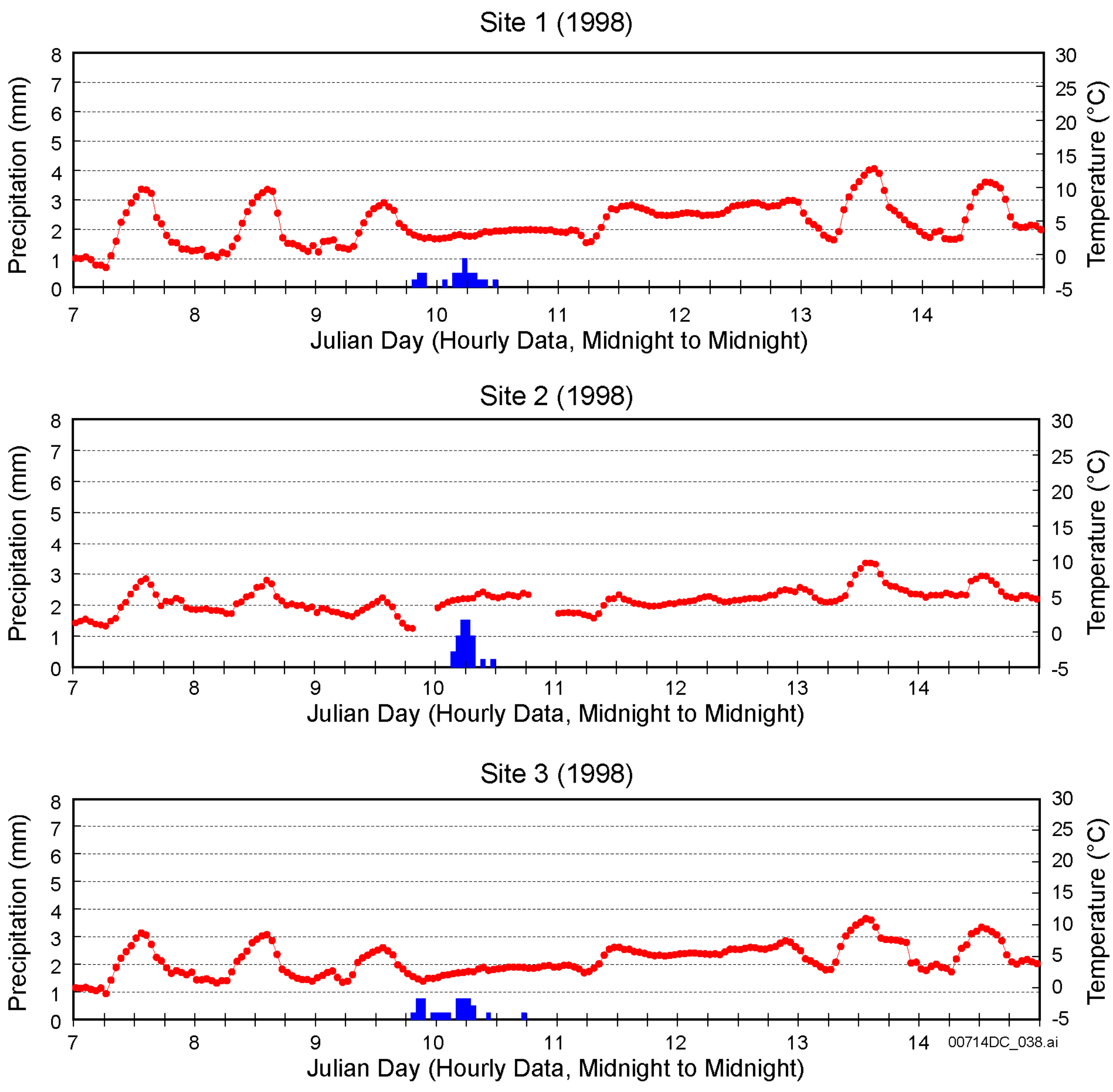
Appendix D also includes plots for precipitation events during 2002, the driest year in the 12-year period, and plots for precipitation events during 1995, the year during which cumulative precipitation most closely represented a precipitation "mode" year during the 12-year period. The overlay plots (Figures 6.1-30 through 6.1-47) reveal several salient points about the precipitation–temperature relationship. These are:

- A decrease in hourly and daily maximum temperatures usually occurs within 5 to 48 hours of a precipitation event (the decrease can precede or follow the precipitation event).

- Depending on the time of year and the station elevation, the minimum temperature can increase during a precipitation event (e.g., the minimum temperature can increase if an overnight period of cloud cover precedes a winter precipitation event, and prevents long-wave radiation from escaping into space).

- A temperature drop, coincident with an isolated precipitation event that occurs at one site, can be seen at another site that does not experience a precipitation event.

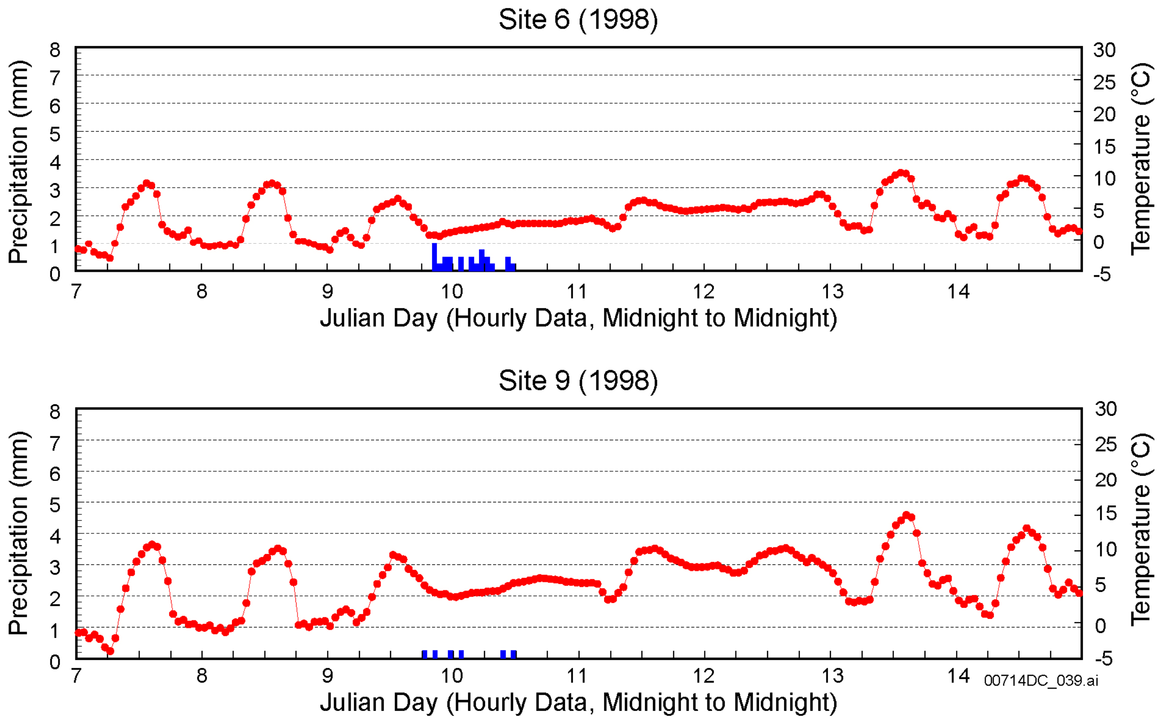
The plotted temperature profile and precipitation pulse recorded for Julian days 7 through 14 are shown in Figures 6.1-30 and 6.1-31. During this period, precipitation began late at night, and extended into the early morning hours.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-30. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 7 through 14



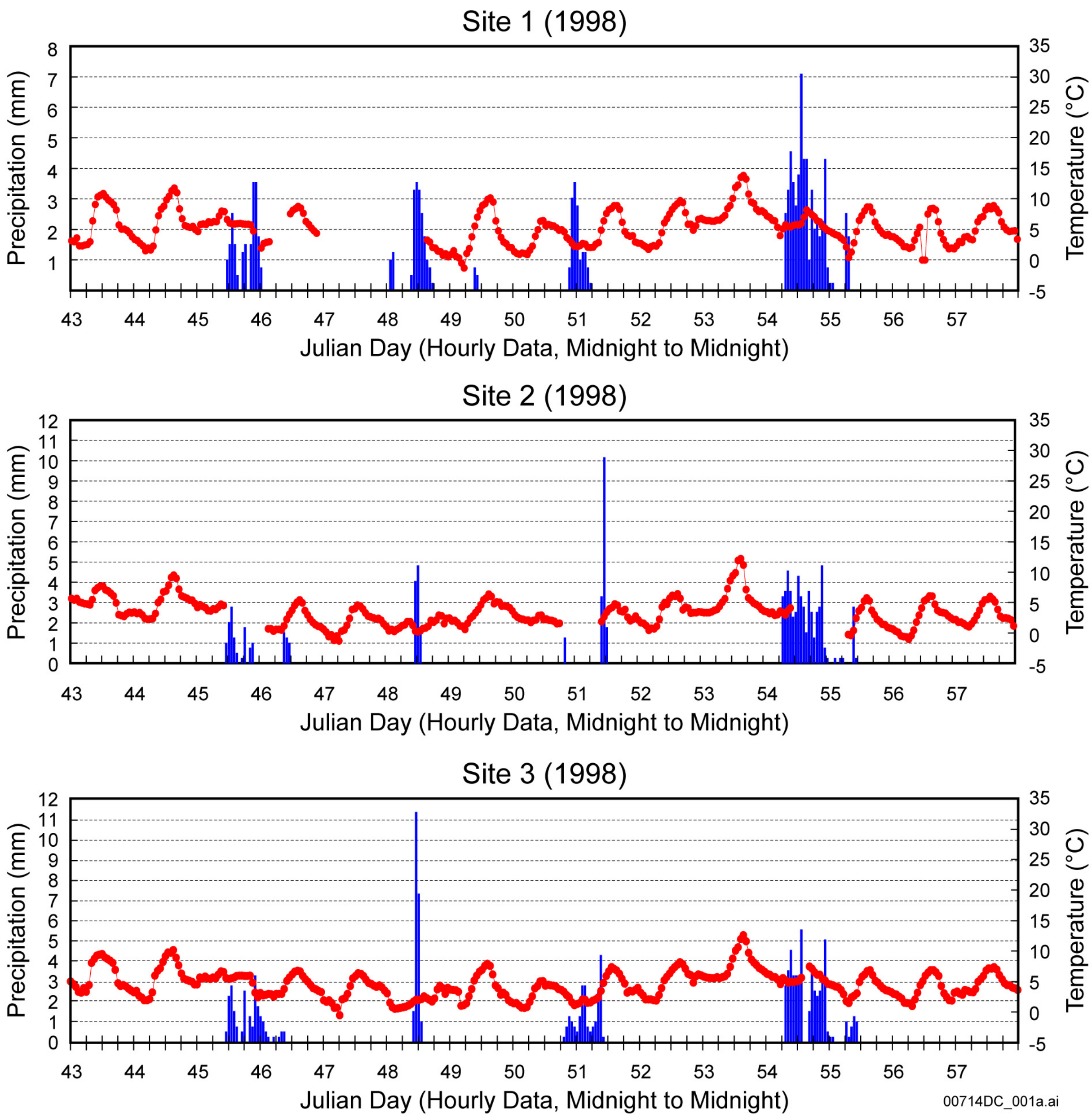
Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-31. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 7 through 14

Prior to the precipitation event, the temperature profile has very distinct peaks and valleys at all five sites. Hours before and several days after a precipitation event, temperatures flatten out. Generally, maximum temperature decreases and minimum temperature increases.

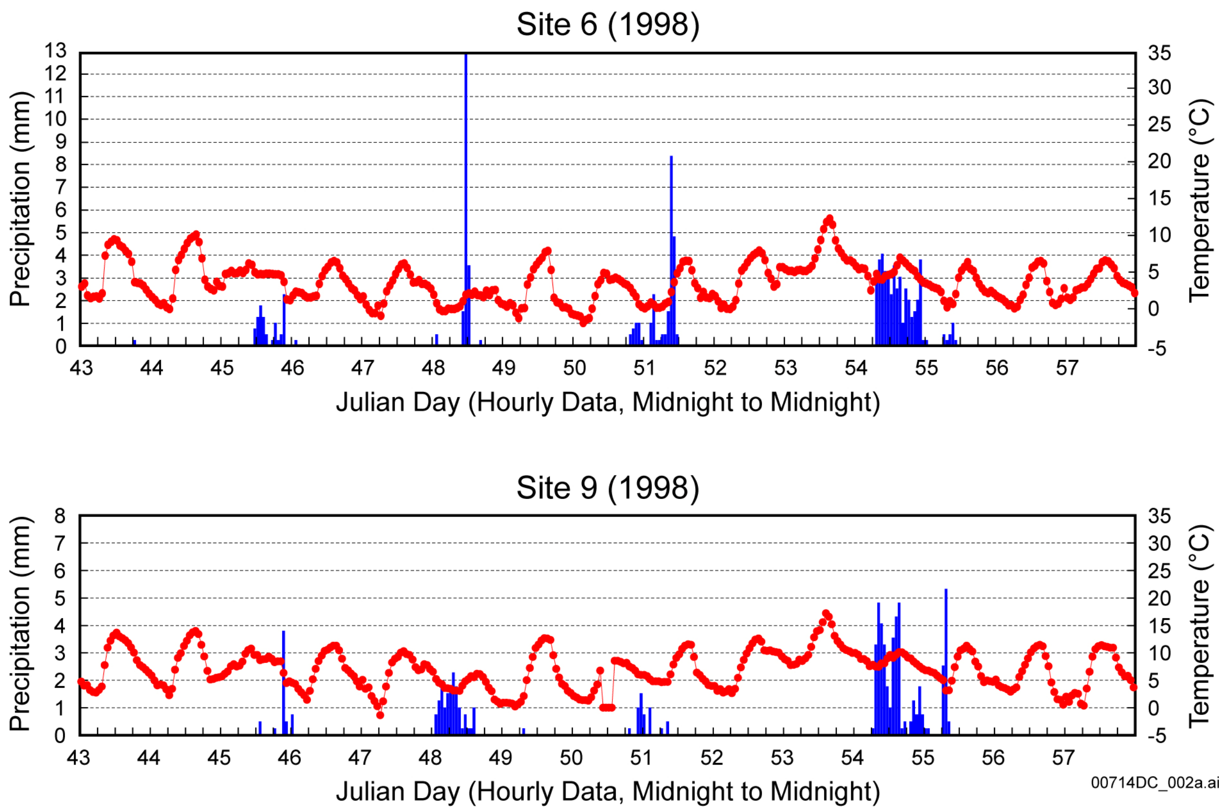
The plotted temperature profile and precipitation pulse recorded for Julian days 43 through 57 are shown in Figures 6.1-32 and 6.1-33. During this period, precipitation events are clustered together, last 6 to 18 hours, and occur frequently. These precipitation clusters are separated by only one or two days. A precipitation event tends to be coincident with a downward shift (2°C to 5°C) in the temperature profile.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-32. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 43 through 57



Source: See Appendix F.

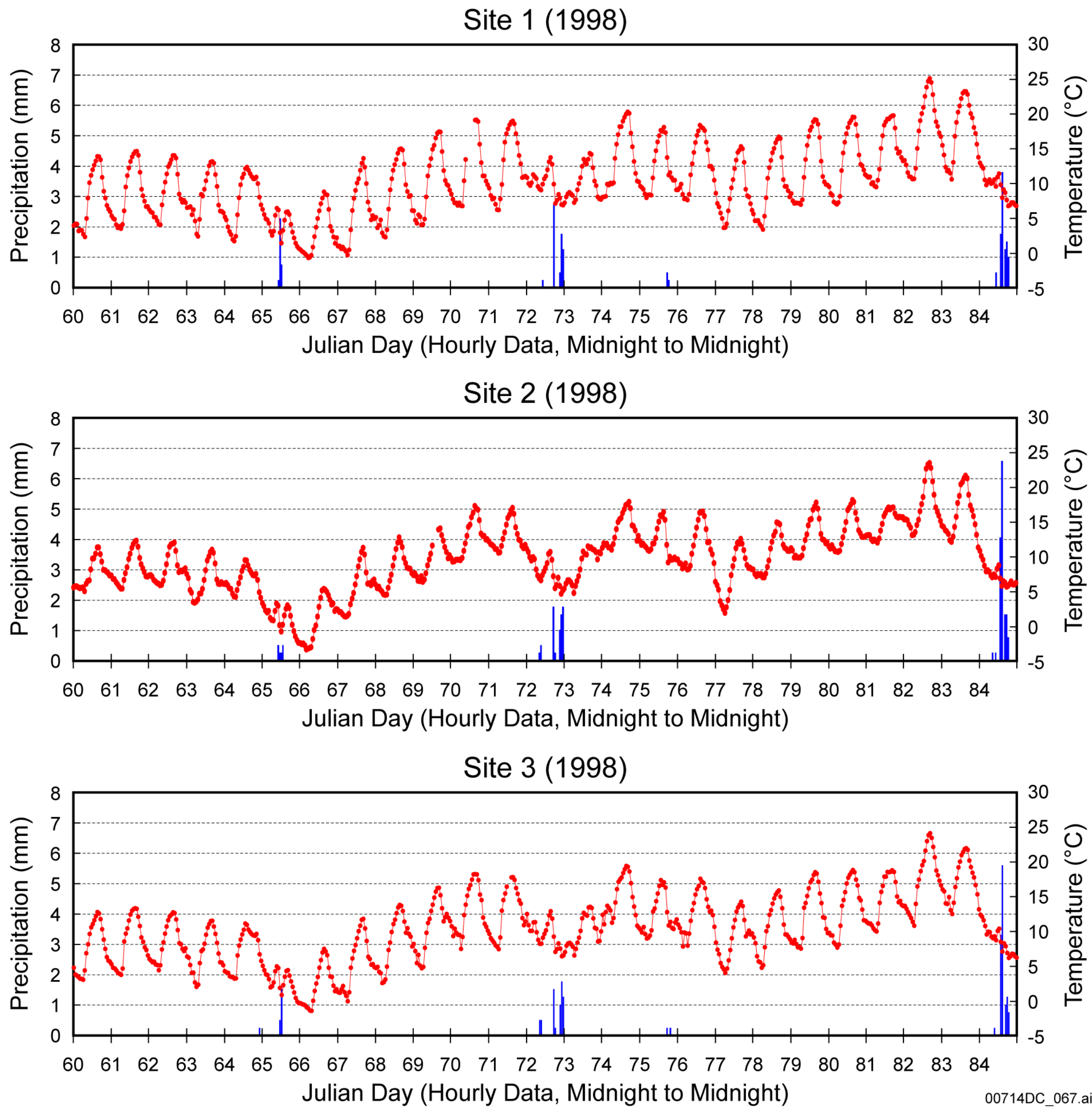
NOTE: Temperature and precipitation are plotted as hourly data. Maximum value for Site 6 = 12.954 mm.

Figure 6.1-33. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 43 through 57

The plotted temperature profile and precipitation events recorded for Julian days 60 through 84 are shown in Figures 6.1-34 and 6.1-35. This is a relatively dry period during which small, isolated precipitation events occur. Precipitation marks a one to one-and-one-half day interruption in the temperature cycle, and coincides with a brief drop (10°C to 15°C) in the maximum temperature.

Depending on the elevation, the minimum temperature could decrease during precipitation (but, as noted earlier, this is not always the case; at YM Sites 6 and 9, the minimum temperature actually increased by a few degrees during several precipitation events, although the maximum temperature decreased). After precipitation ends, cyclic temperature patterns resume within one to two days.

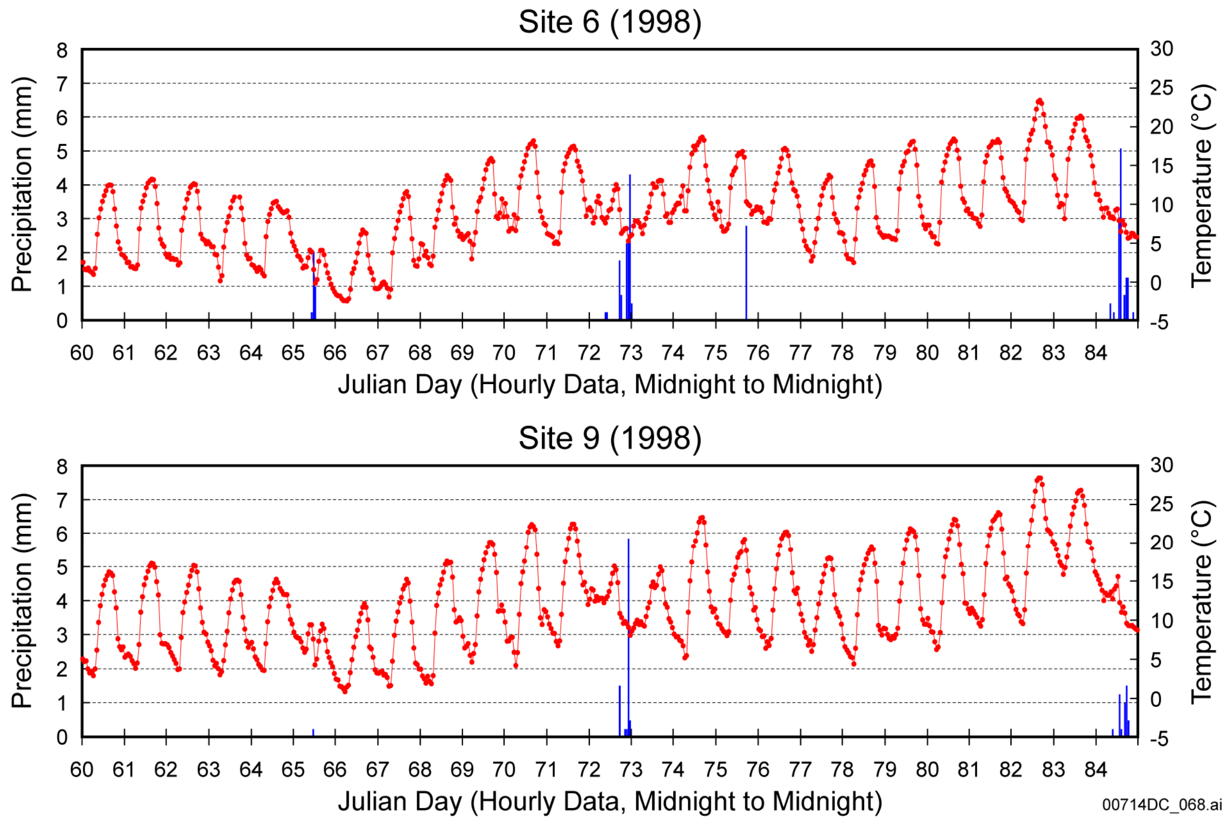
Figures 6.1-34 and 6.1-35 show that YM Site 1 had a significant precipitation event on Julian day 64, concurrent with a temperature drop, while YM Site 9 has a similar temperature drop on Julian day 65, yet minimal precipitation is recorded for the day.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-34. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 60 through 84



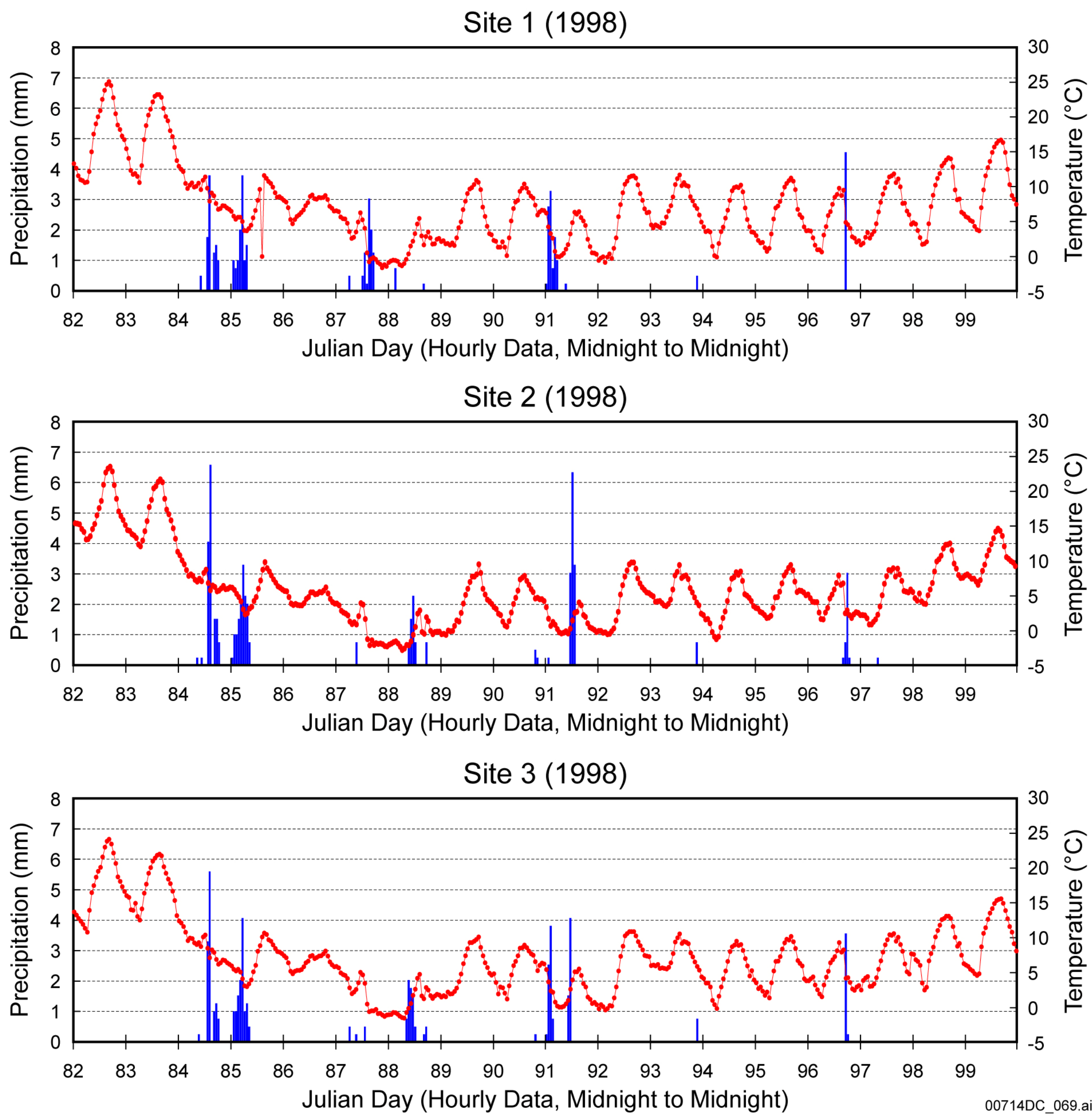
Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-35. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 60 through 84

Plotted temperature profile and precipitation events recorded for Julian days 82 through 99 are shown in Figures 6.1-36 and 6.1-37. A wet period begins around Julian day 84 or 85, and lasts 15 to 16 days. During this period, precipitation occurs every three to four days, and is accompanied by a downward temperature-profile shift that persists for the entire 15- to 16-day period.

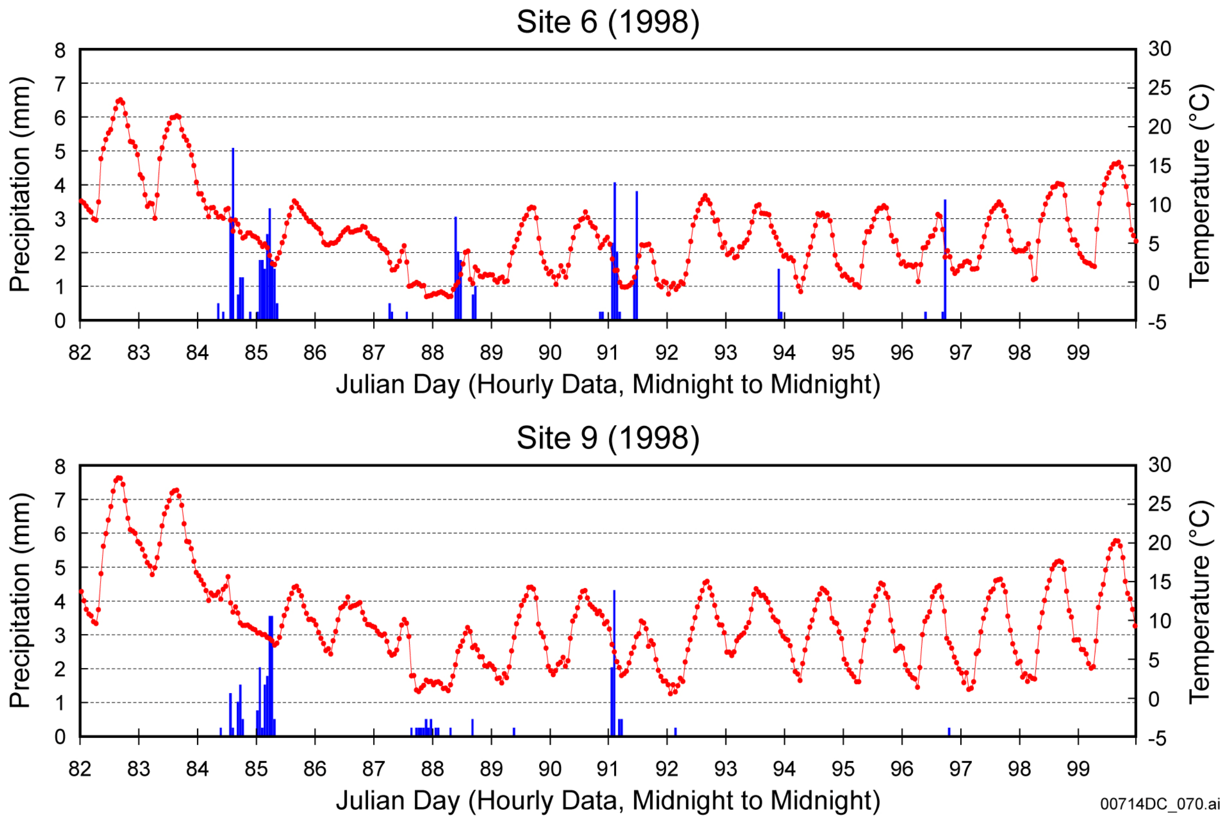
Figures 6.1-36 and 6.1-37 show that YM Site 9 experiences a downward temperature shift, coincident with precipitation that occurs at YM Sites 1, 2, 3, and 6, even though during this period YM Site 9 has far less precipitation than the other sites, has no precipitation on Julian day 94, and has very little precipitation on Julian days 88 and 97.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-36. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 82 through 99

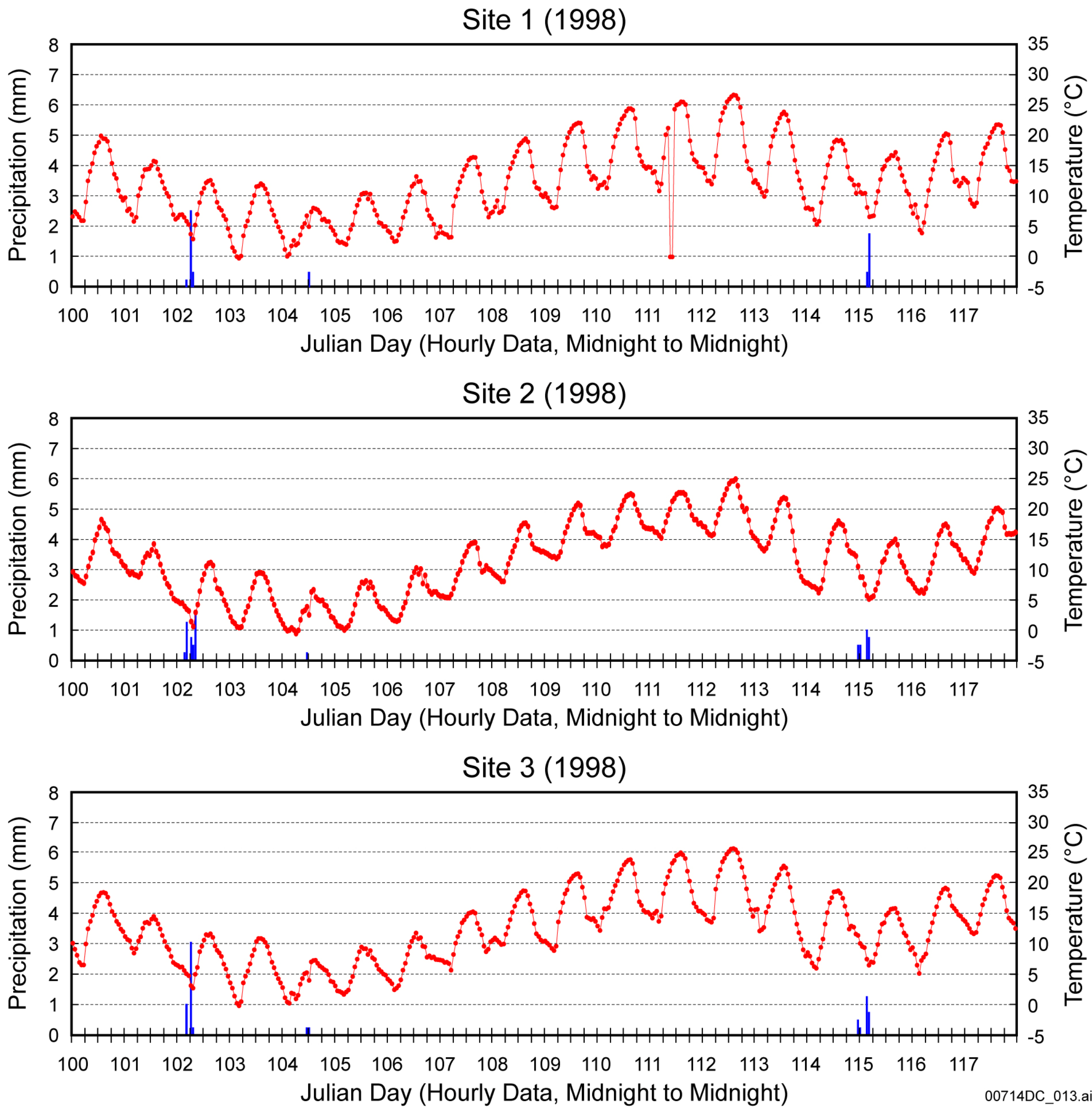


Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-37. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 82 through 99

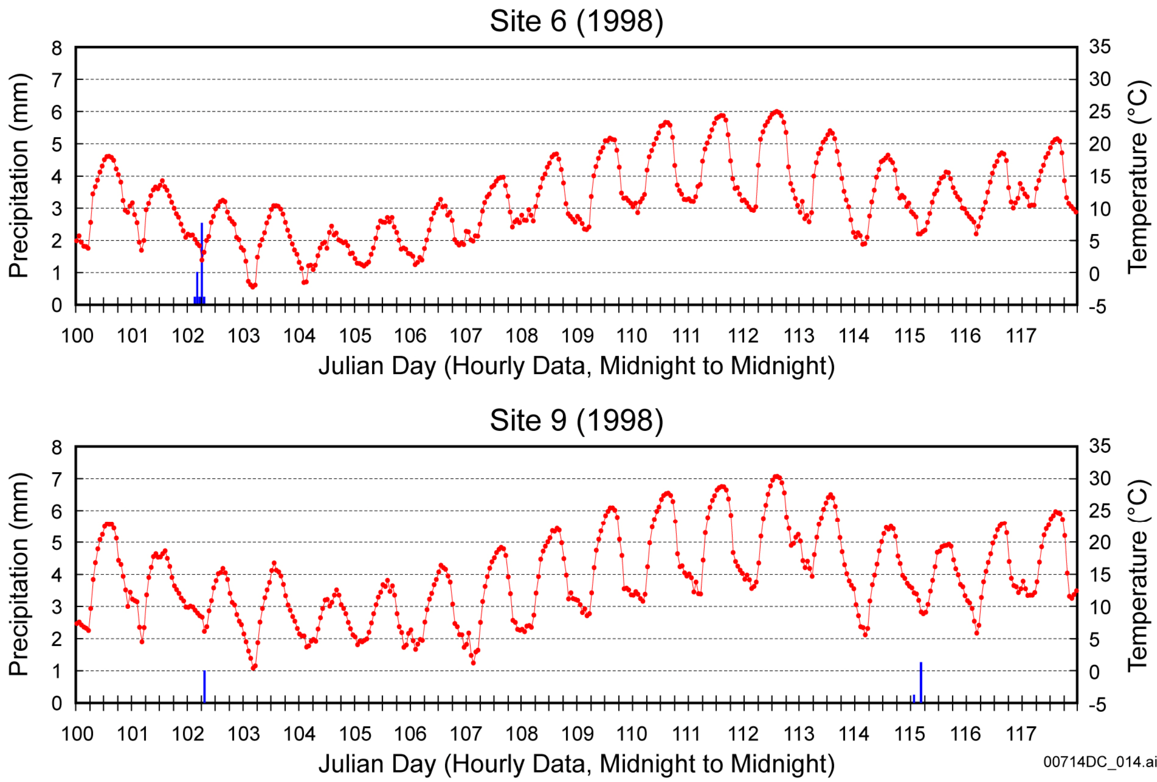
Plotted temperature profile and precipitation events recorded for Julian days 100 through 117 are shown in Figures 6.1-38 and 6.1-39. Precipitation events that occur after Julian day 100 cause the temperature profile to shift downward. Two days before the precipitation event, temperature maximum and minimum values begin to decline, likely due to the passage of a series of weak frontal systems. The temperature is seen to decline by 5°C to 10°C, depending on the station, with the greatest changes occurring at YM Site 9. Despite the downward temperature shift, the temperature profile maintains a characteristic diurnal saw-tooth profile throughout the 20-day period.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-38. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 100 through 117



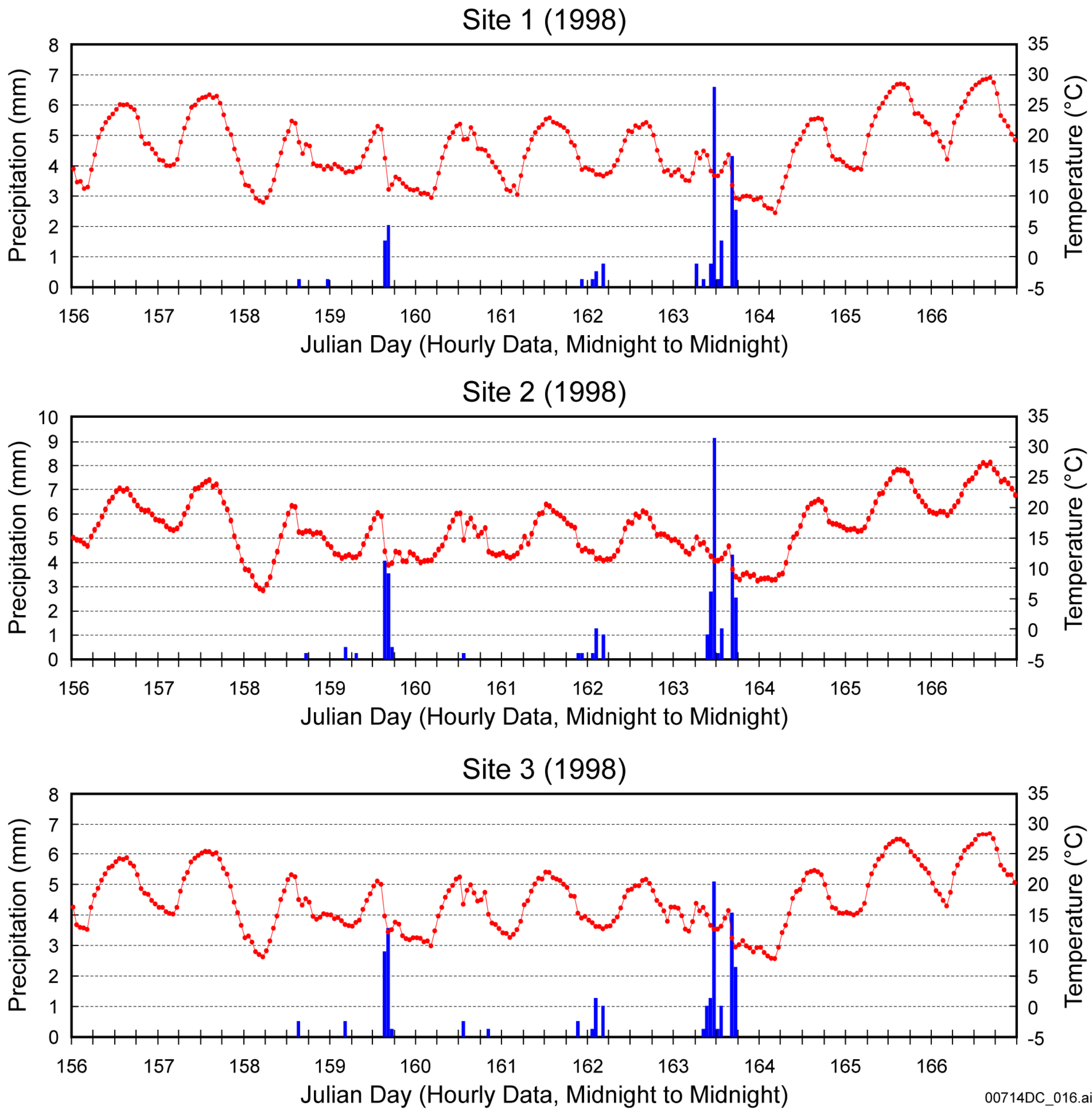
Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-39. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 100 through 117

Plotted temperature profile and precipitation events recorded for Julian days 156 through 166 are shown in Figures 6.1-40 and 6.1-41. The temperature had been increasing for approximately 60 days preceding this period, and would continue to climb for approximately 40 more days. Precipitation events are less frequent during this time period than during the previous 60 days. Maximum temperature decreases by approximately 5°C the day before, and during, a precipitation event.

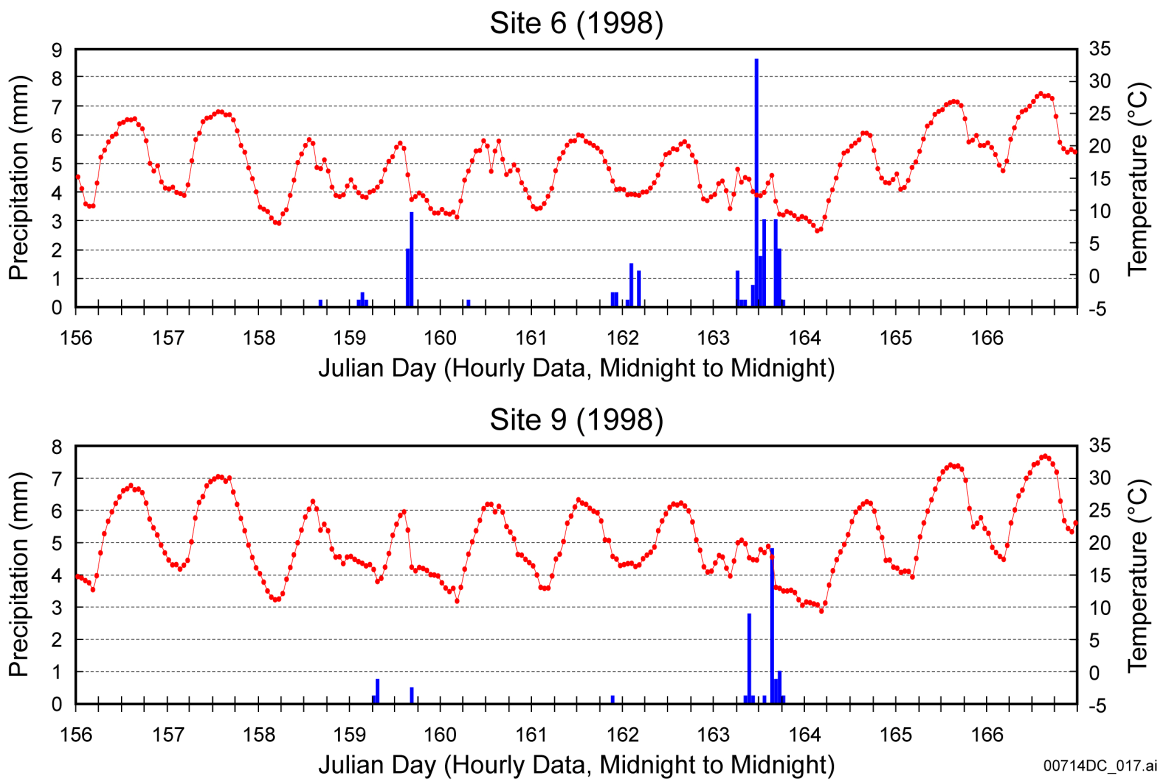
At the higher-elevation locations (YM Sites 1, 2, and 3), minimum temperatures increase before and concurrent with a precipitation event, possibly due to the passage of large-scale storms with associated cloud cover. As noted earlier, the cloud cover caps the ground warmth, and prevents the rapid cooling normally associated with clear skies.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-40. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 156 through 166

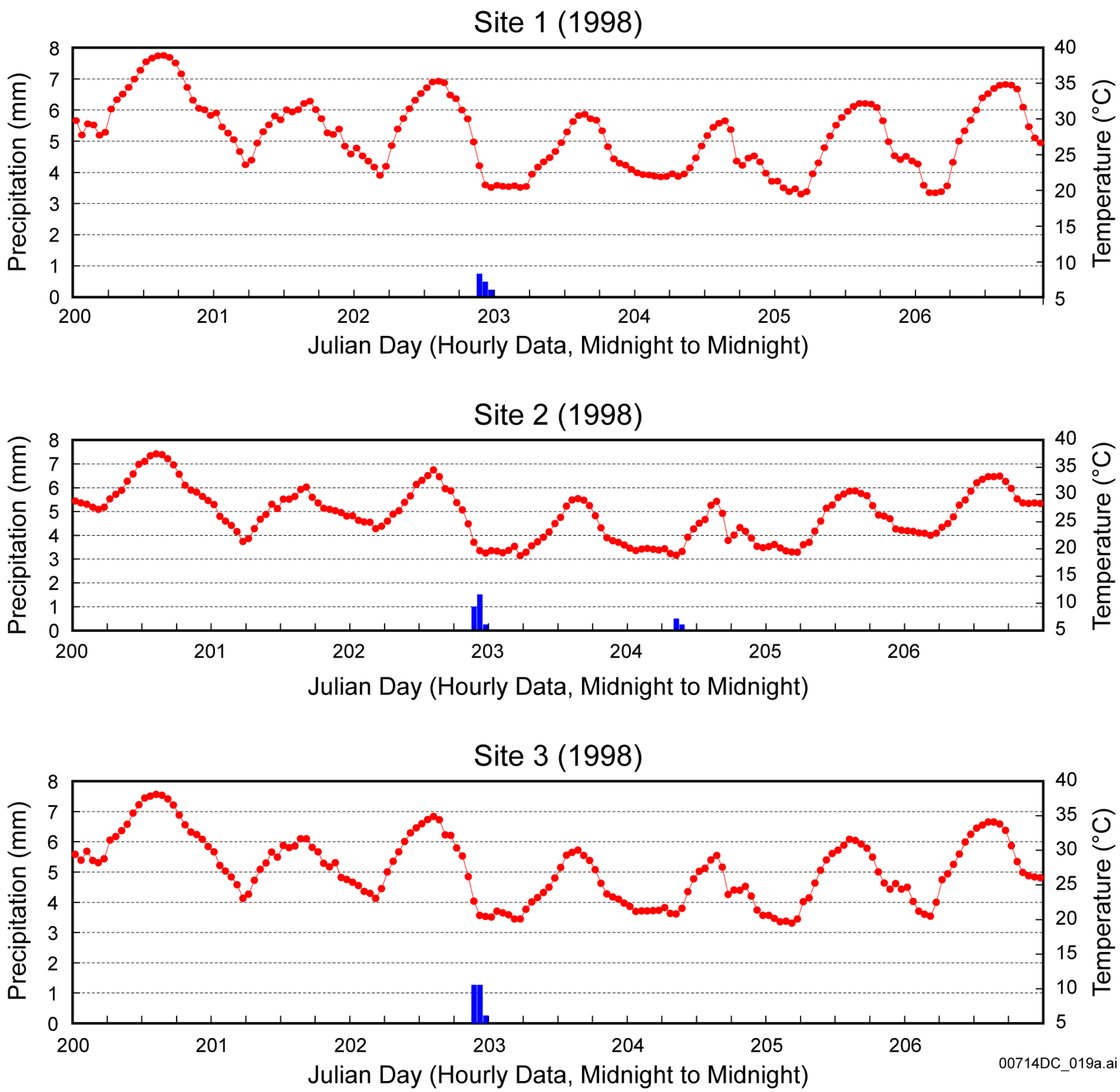


Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-41. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 156 through 166

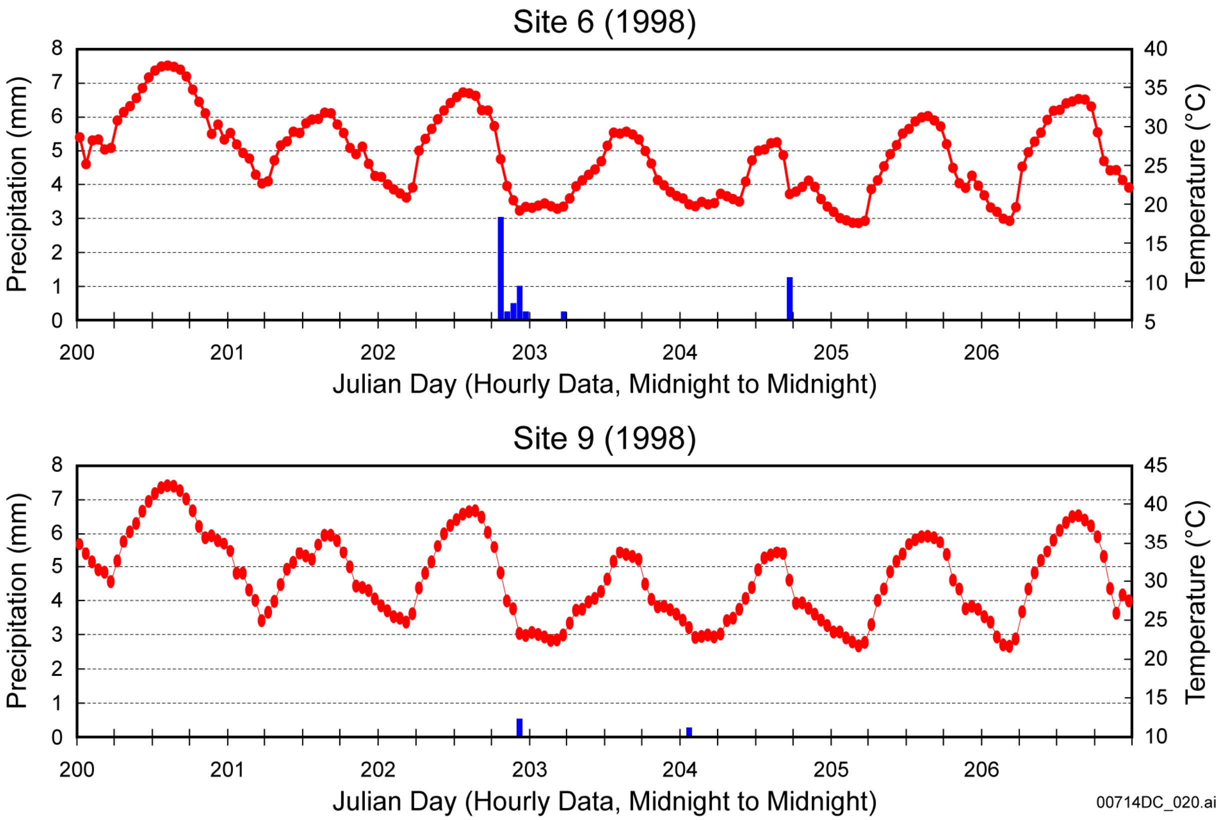
Plotted temperature profile and precipitation events recorded for Julian days 200 through 206 are shown in Figures 6.1-42 and 6.1-43. These were the hottest days of the year. Coincident with a precipitation event, maximum and minimum temperatures are reduced, and maximum temperature is reduced to a greater extent than minimum temperature (minimum temperature is reduced, at most, by 2°C to 3°C; maximum temperature is reduced by approximately 5°C to 7°C).



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-42. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 200 through 206

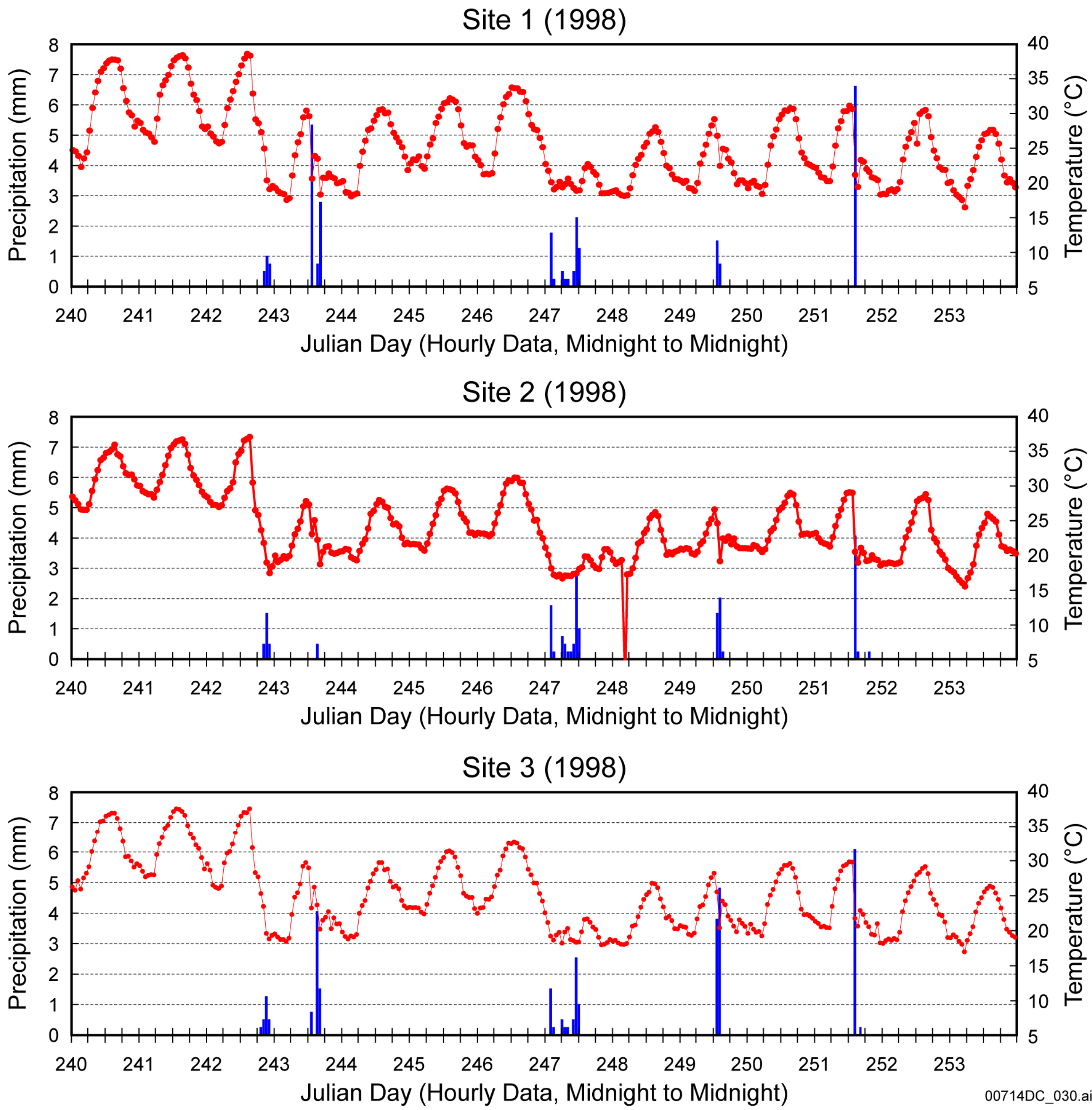


Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-43. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 200 through 206

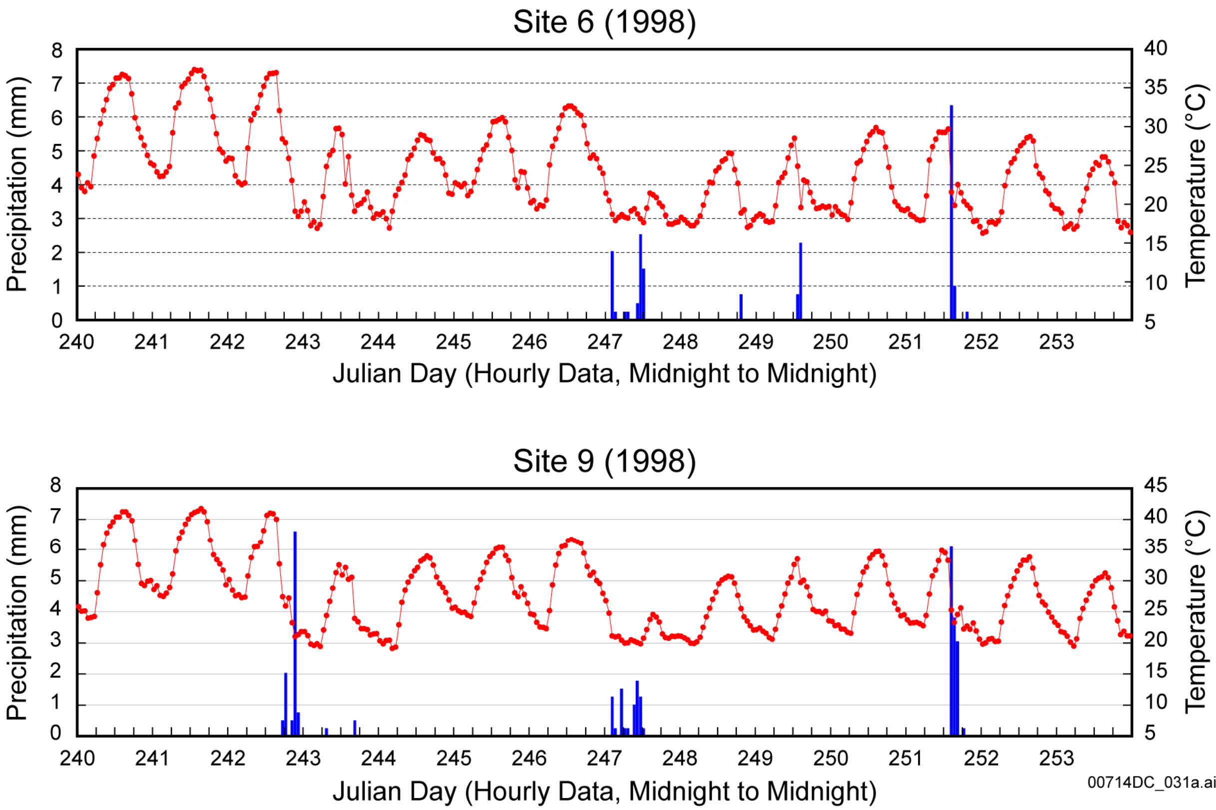
Plotted temperature profile and precipitation events recorded for Julian days 240 through 253 are shown in Figures 6.1-44 and 6.1-45. Temperatures are still hot during this period, and precipitation events begin to increase in frequency, and occur as brief, intense events. During a precipitation event, the temperature profile shifts downward by approximately 5°C to 10°C, maintaining a diurnal saw-tooth profile before and after precipitation.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-44. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 240 through 253

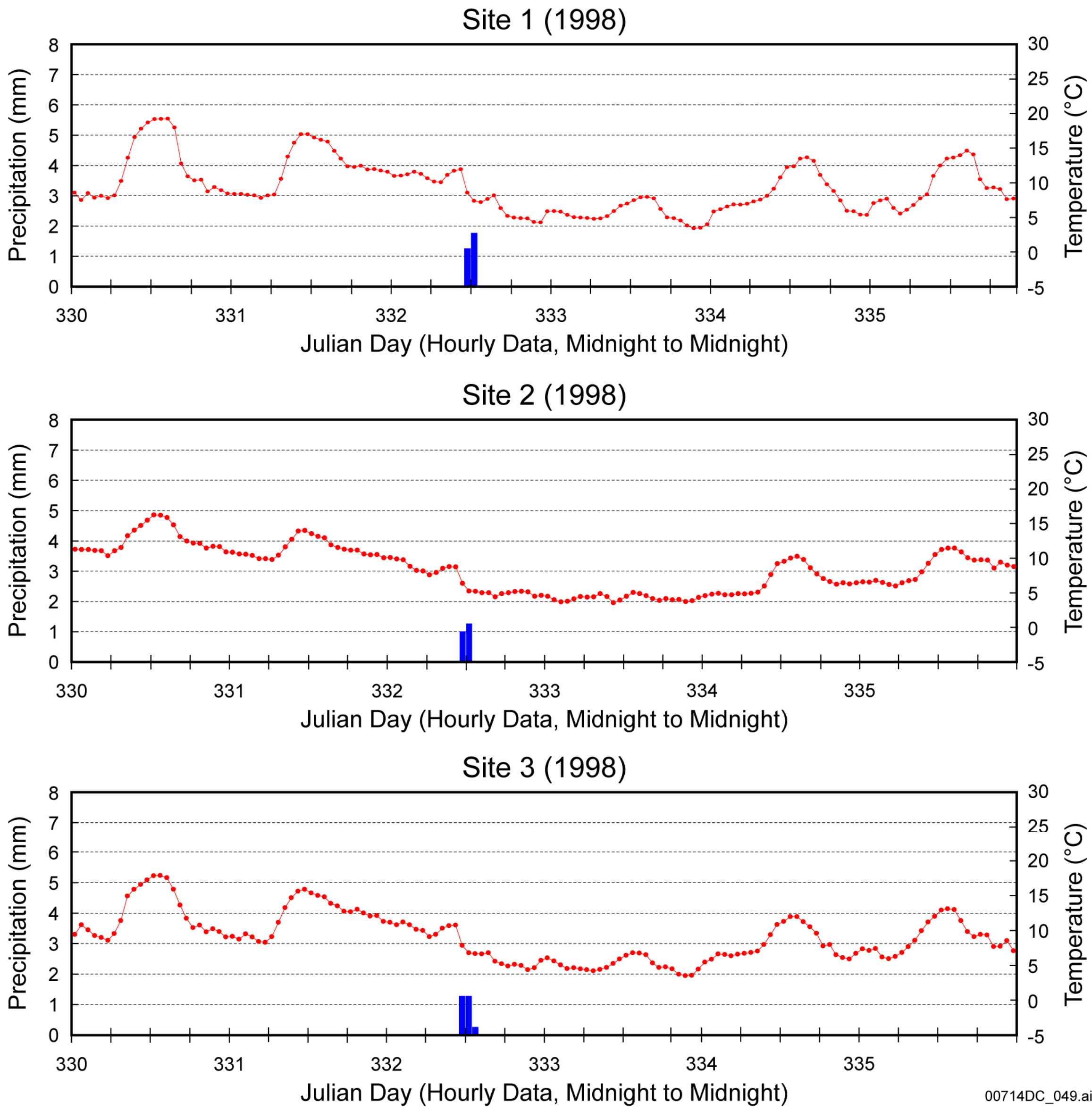


Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-45. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 240 through 253

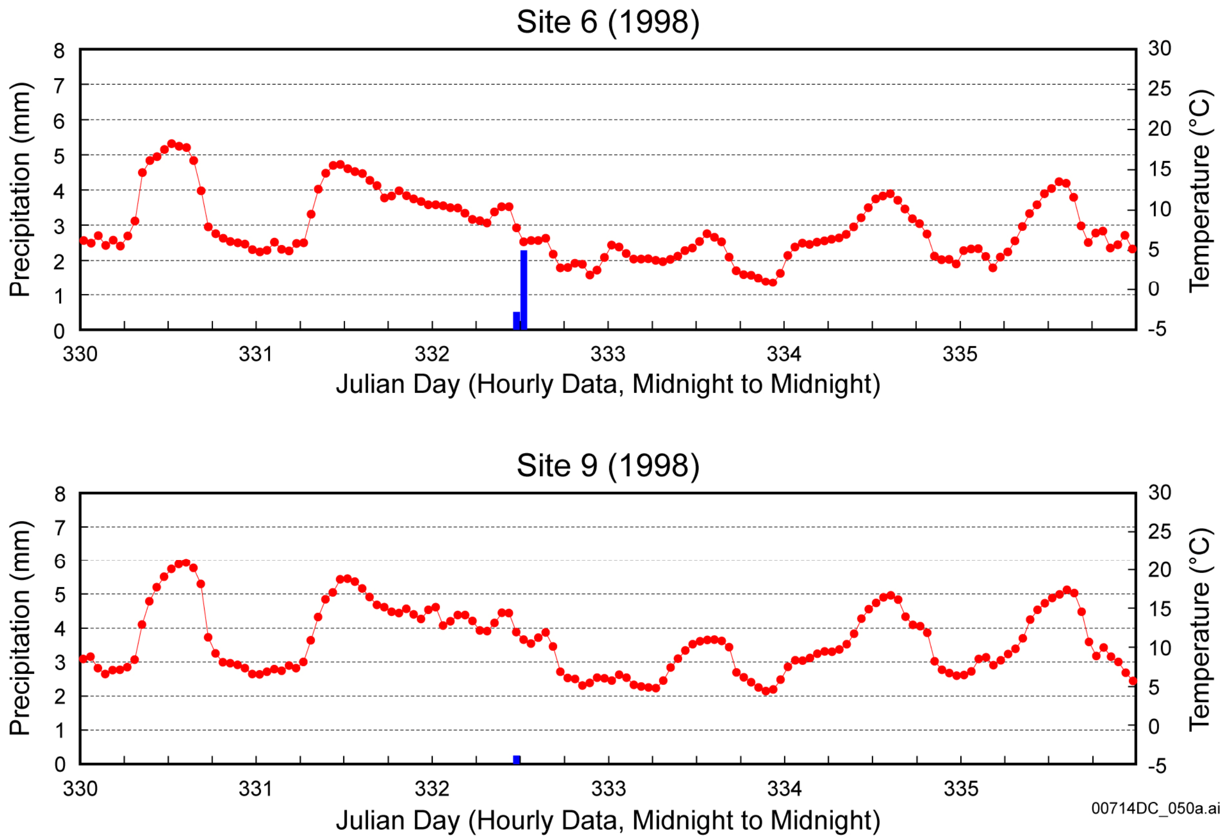
Plotted temperature profile and precipitation events recorded for Julian days 330 through 335 are shown in Figures 6.1-46 and 6.1-47. During this period, temperatures are within 20 days of reaching their lowest values of the 365-day cycle. At higher elevations, minimum and maximum temperatures flatten out a day before and during a precipitation event, remaining within 2°C to 3°C, for one to two days after the event. At the lowest-elevation site (YM Site 9), the difference between the maximum and minimum temperatures is approximately 2°C to 7°C.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-46. Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 330 through 335



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-47. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 330 through 335

6.1.5.5 Wind Speed

Figures 6.1-48 through 6.1-52 show scatter plots of all daily wind speed averages for YM Sites 1, 2, 3, 6, and 9 for the period from 1993 through 2004. Data from Sites 1, 2 and 9 cover all 12 years, but the wind data from Site 3 and Site 6 end during 1999. Individual daily average wind speeds during the period were used to calculate average wind speeds for each day of the year, which are shown in Figures 6.1-48 through 6.1-52.

Figure 6.1-53 contains scatter plots of the daily averages calculated for the whole period by site. The figure also shows third-order polynomial trend lines fitted to the individual site daily averages, and the equations used to plot the trend lines. These lines were added to show similar seasonal variations among the sites, without attempting to distinguish which line was associated with a given site data set. The point of the presentation is to visualize the common seasonal pattern evident at all sites, differing mostly by mean value.

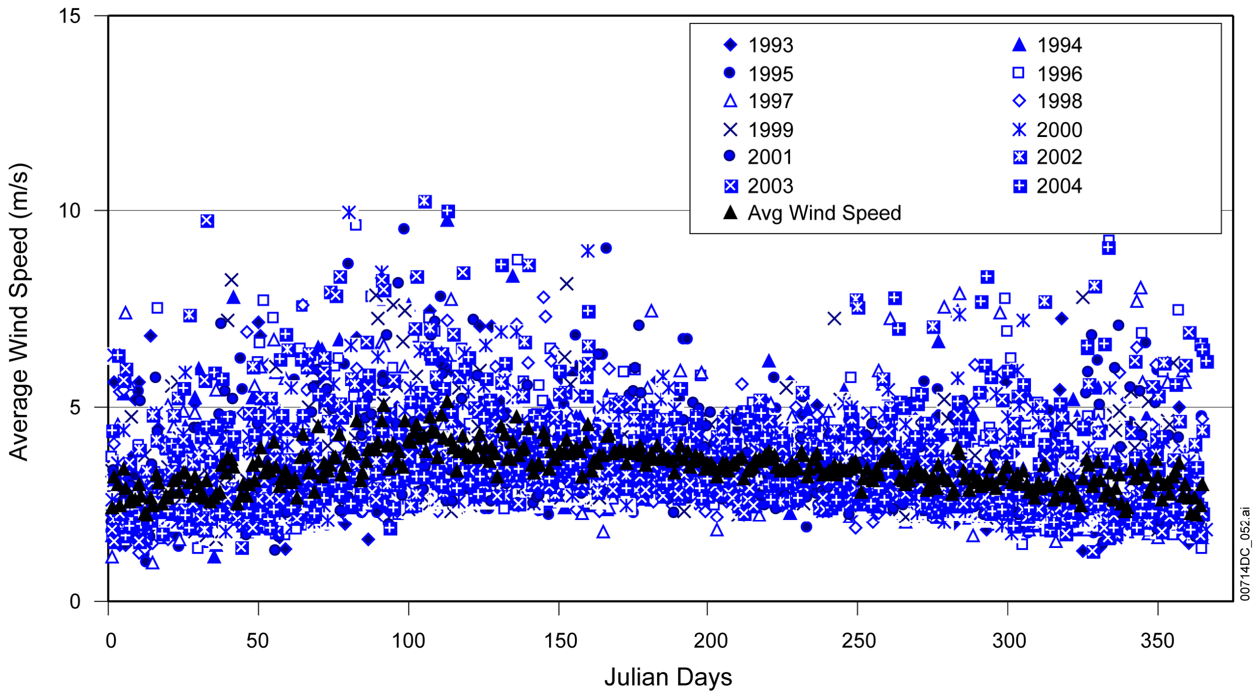
The overall average for each Site, and the peak daily value from the overall daily averages, are shown in Table 6.1-10. Observations noted on these data include the following points:

1. YM Site 9 has the highest 12-year-average wind speed, closely followed by YM Site 2, which tends to be windier during spring and less windy during fall than YM Site 9.
2. YM Site 3 has the lowest average wind speed calculated (Note: YM Site 3 wind speed averaged for years 1993 through Julian day 195 of 1999).
3. Wind speeds peak, at all sites, around the vernal equinox (Julian day 81 or 82).
4. The highest "single day" 12-year-average wind speed occurs at YM Site 2.
5. The lowest "single day" 12-year-average wind speed occurs at YM Site 3.

The average wind speed for each of the five sites over the 12-year period, and the single "windiest average day" over the 12-year period for the five sites, are shown in Figure 6.1-53.

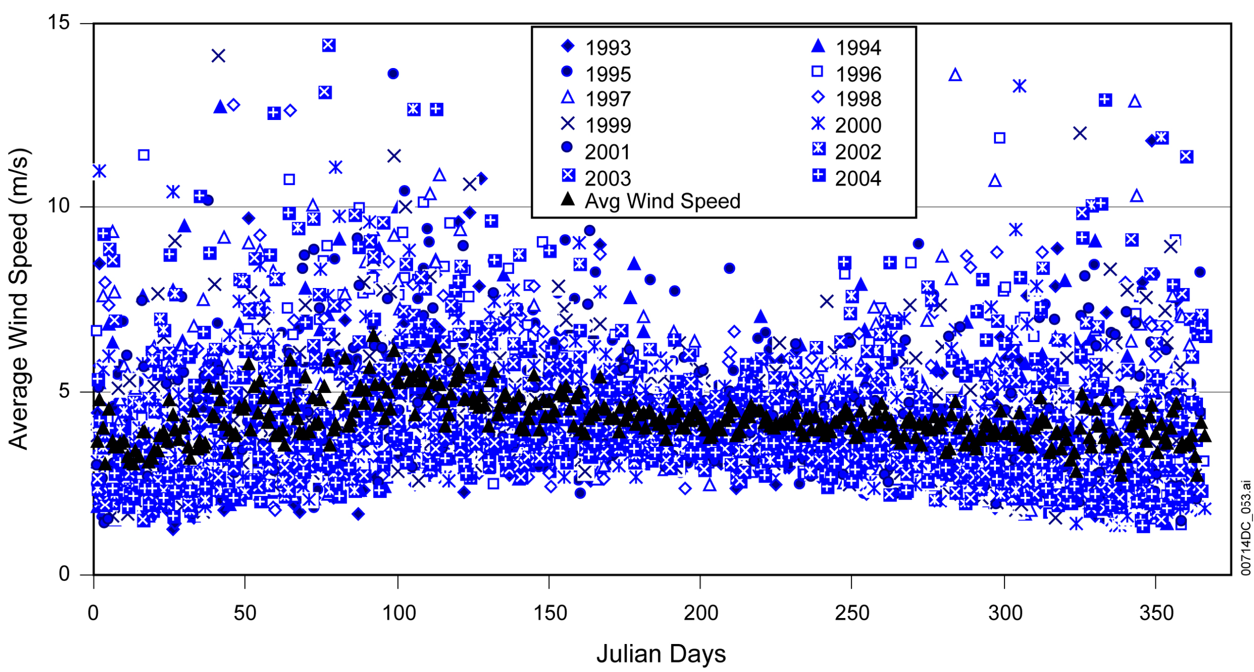
Table 6.1-10. Average and Peak Average Wind Speeds for YM Sites 1, 2, and 9 (1993 through 2004), and Average and Peak Average Wind Speeds for YM Sites 3 and 6 (1993 through Julian day 195, 1999)

Site	Julian Day	Peak Average Wind Speed (m/s)	Average Wind Speed (m/s)
YM Site 1	113	5.2	3.5
YM Site 2	92	6.6	4.3
YM Site 3	83	4.4	2.7
YM Site 6	83	6.2	4.0
YM Site 9	107	5.8	4.4



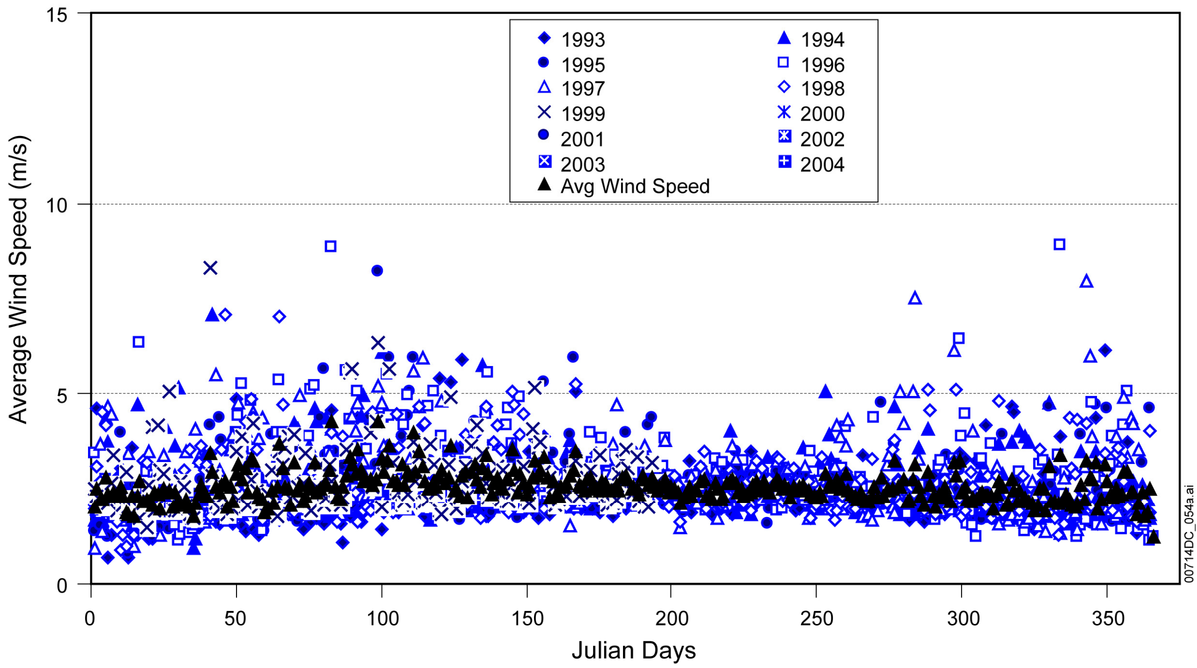
Source: See Appendix F.

Figure 6.1-48. YM Site 1 Average Daily Wind Speed (1993 through 2004)



Source: See Appendix F.

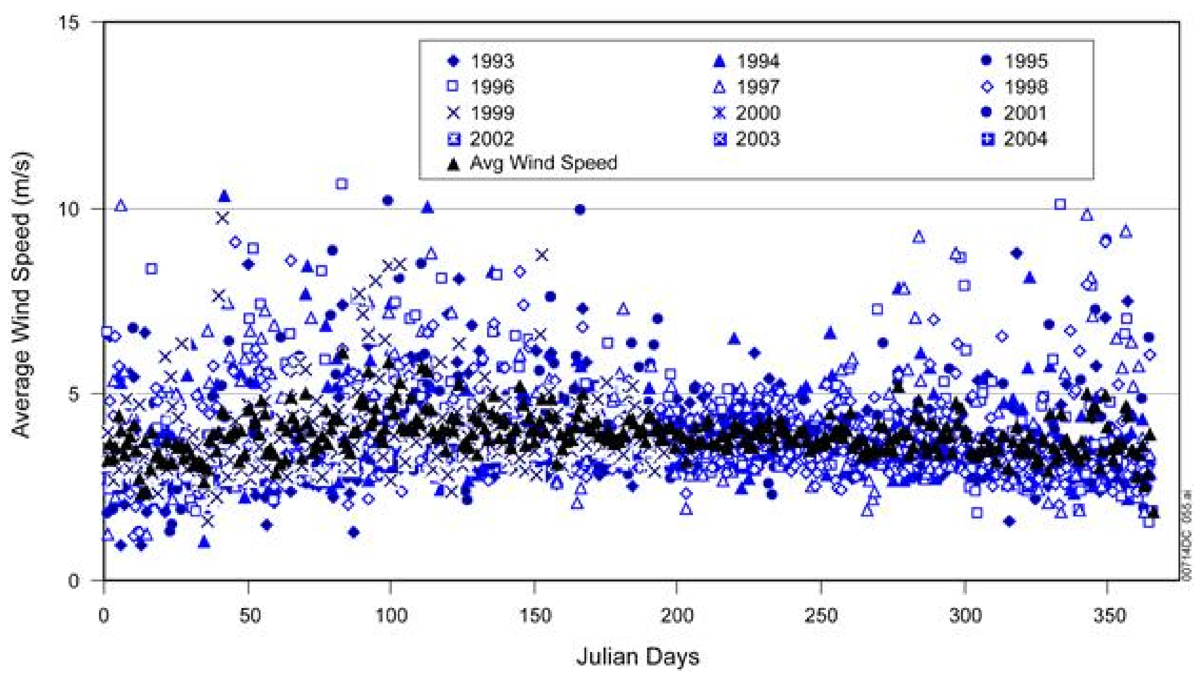
Figure 6.1-49. YM Site 2 Average Daily Wind Speed (1993 through 2004)



Source: See Appendix F.

NOTE: Wind speed not measured at YM Sites 3 and 6 after mid 1999.

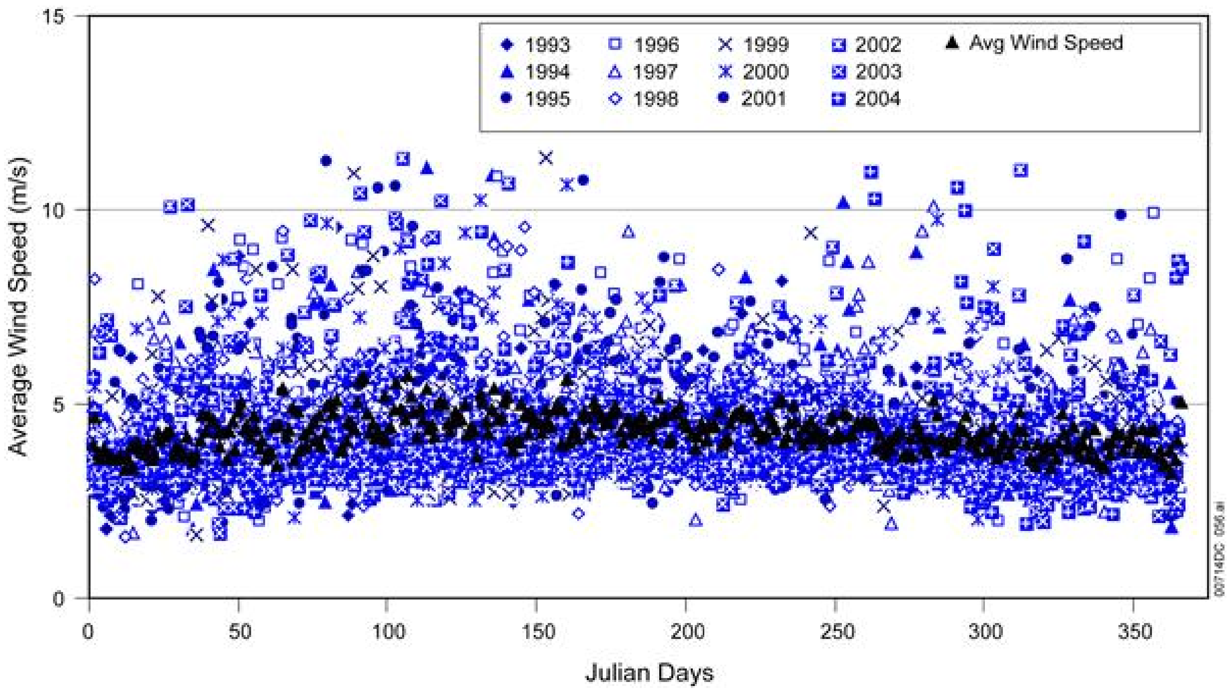
Figure 6.1-50. YM Site 3 Average Daily Wind Speed (1993 through Julian day 195, 1999)



Source: See Appendix F.

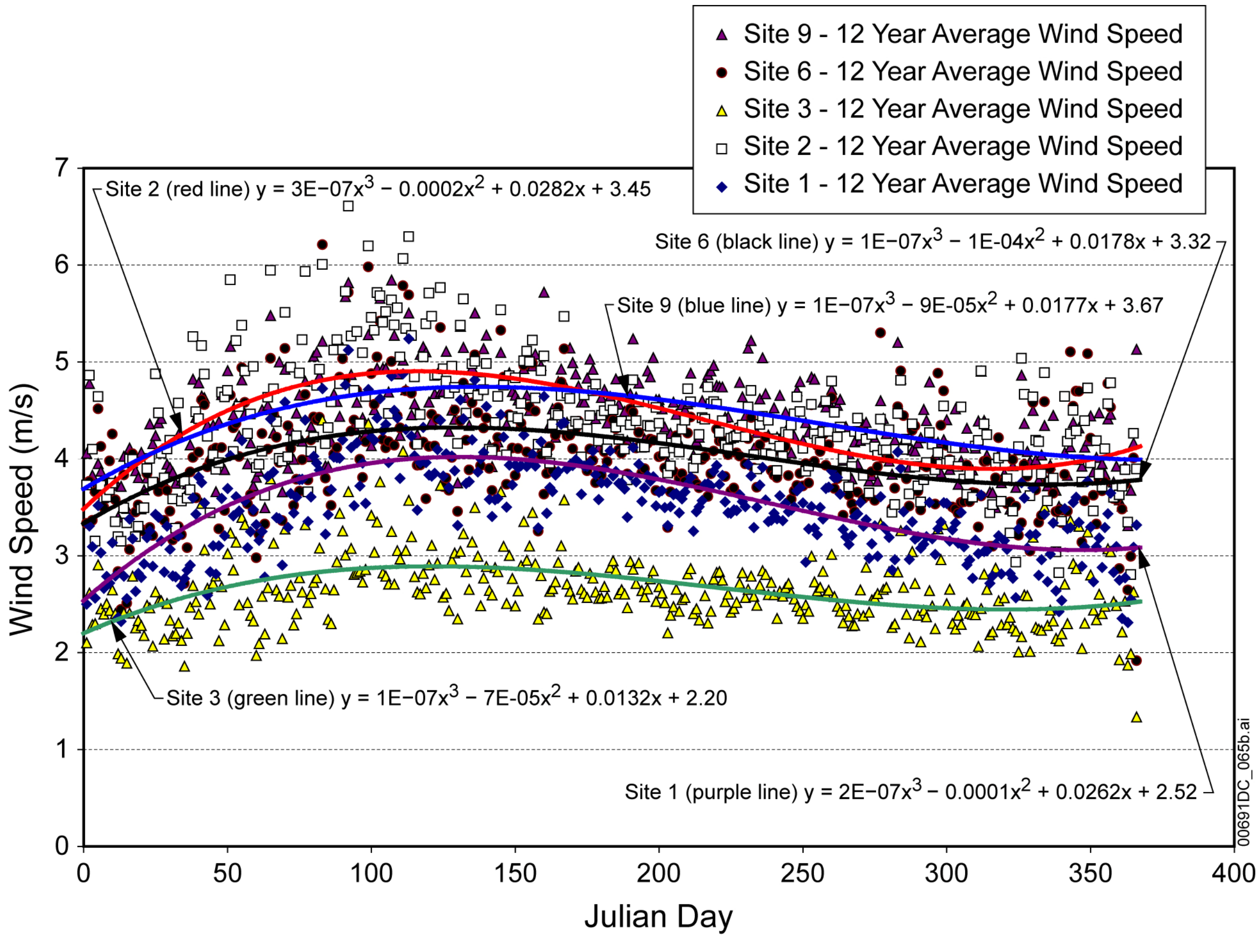
NOTE: Wind speed not measured at YM Sites 3 and 6 after mid 1999.

Figure 6.1-51. YM Site 6 Average Daily Wind Speed (1993 through Julian day 195, 1999)



Source: See Appendix F.

Figure 6.1-52. YM Site 9 Average Daily Wind Speed (1993 through 2004)



Source: See Appendix F

NOTES: Curves and equations are polynomial fits to data.

The trend lines shown do not distinguish between sites. The seasonal pattern occurring at all sites is discussed in Section 6.1.5.5.

Figure 6.1-53. Twelve-Year Average Daily Wind Speed for YM Sites 1, 2, and 9 (1993 through 2004), Six-and-a-Half-Year Average Daily Wind Speed for YM Sites 3 and 6 (1993 through 1998 and the first 195 days in 1999)

6.2 METEOROLOGIC DATA FROM THE NEVADA TEST SITE AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION COOPERATIVE OBSERVER DATA REPRESENTATIVE OF PRESENT-DAY CLIMATE CONDITIONS

Five locations within a 40 km radius of Yucca Mountain were selected to represent present-day climate conditions for the Yucca Mountain region, from which site data were incorporated into output DTN: SN0601PRECPTMP.002. Meteorological data from these locations are intended for use as inputs for present-day climate conditions for use in infiltration modeling. Four of the five locations maintained by NOAA/ARL/SORD are situated on the NTS: Area 12, Cane Springs, 40MN, and Site 4JA. Data from these locations contain only precipitation records. The fifth location, Amargosa Farms–Garey, located off the NTS, is a NOAA cooperative meteorological station that maintains temperature data in addition to precipitation records. Source data used to generate output DTN: SN0601PRECPTMP.002 are from DTN: SN0512NOAADATA.002 [DIRS 176099], *SNL acquired precip data_Present Climate_Final.xls*, and from the EarthInfo® summary file (NCDC 1998 [DIRS 135900]).

6.2.1 Data Extraction

Precipitation data, measured in inches, were extracted from DTN: SN0512NOAADATA.002 [DIRS 176099] for output DTN: SN0601PRECPTMP.002; DTN: SN0512NOAADATA.002 [DIRS 176099] also includes records from numerous precipitation stations (on the NTS) that are not needed for this analysis. The source data includes the following worksheets (one for each decade):

- NCDC precipitation data
- NTS (1950's [sic]) precip data
- NTS (1960's [sic]) precip data
- NTS (1970's [sic]) precip data
- NTS (1980's [sic]) precip data
- NTS (1990's [sic]) precip data
- NTS (2000's [sic]) precip data.

Only precipitation records from the Area 12, Cane Springs, 40MN, and Site 4JA stations were extracted from NTS yearly worksheets in DTN: SN0512NOAADATA.002 [DIRS 176099], for the development of output DTN: SN0601PRECPTMP.002. Precipitation and temperature data for Amargosa Farms–Garey were obtained from two sources, DTN: SN0512NOAADATA.002 [DIRS 176099], worksheet "NCDC precipitation data"; and the EarthInfo® summary file (NCDC 1998 [DIRS 135900], State of Nevada, Station Amargosa Farms–Garey). Precipitation data from DTN: SN0512NOAADATA.002 [DIRS 176099] were recorded during the period December 1965 through December 2005; minimum and maximum daily temperature data, recorded during the period 1998 through 2005 in degrees Fahrenheit, are located at the bottom of the worksheet. Minimum and maximum daily temperatures for the period December 1965 through December 1997 were extracted from the EarthInfo® summary file (NCDC 1998 [DIRS 135900], State of Nevada, Station Amargosa Farms–Garey).

6.2.2 Data Processing

For the NTS stations, yearly precipitation data on the source worksheets are listed in columnar form, January through December, by day of month, and with a total listed at the end of the month. One month follows another, with a space separating each month. The first step in processing the data was to delete monthly totals and the spaces separating each month, followed by converting the monthly calendar days to Julian days.

In the source files, invalid data designated by "−9999," "9999," or "-" (a dash) were replaced with an "n/a" designator. This was accomplished through use of the Excel® SEARCH and REPLACE function. Immeasurable traces of precipitation that occurred within a day, denoted by a "T" designator, were likewise replaced with an "n/a" designator.

Precipitation is reported in inches in the source files, and it was necessary to convert these values to millimeters. Converting inches to millimeters was performed by multiplying the data in inches by 25.4, using the Excel® MULTIPLICATION operator.

Temperature is reported in degrees Fahrenheit in the source files. Conversion from degrees Fahrenheit to degrees Celsius is calculated, as discussed in *Quantitative Hydrogeology: Groundwater Hydrology for Engineers* (de Marsily 1986 [DIRS 100439], Table A.2.3), as follows:

$$°C = (°F - 32)5/9$$

Temperature conversion was accomplished using the Excel® CONVERT function. After the source data had been converted to the International System of Units, the data were copied to separate worksheets. Precipitation data for the NTS stations, and both temperature and precipitation data for the Amargosa Farms–Garey station that had been extracted and processed, were transferred to Excel® workbooks (Table 6-2) in output DTN: SN0601PRECPTMP.002; one workbook was created for each of the five stations.

Geographical coordinates for NTS precipitation stations, and for the Amargosa Farms–Garey cooperative station, are given in North American Datum 83 latitude and longitude minute-second units. Station locations were converted from latitude and longitude minute-second to NAD 27 UTM coordinates. This conversion was implemented using CORPSCON (see Section 3.2).

6.2.3 Internal Checking

Data were internally checked to ensure the following:

- If five or more hours of "n/a" designators were recorded for a particular day, then measurements for minimum and maximum values of that day were not derived or transmitted to summary worksheets.

- Data were correctly transmitted from calculation worksheets to summary worksheets.

- Weather station data were downloaded to appropriate (corresponding) Excel® worksheets and workbooks.

- The “−9999,” “9999,” or “-” (dash) designators were replaced with “n/a” designators on summary worksheets.
- The “T” designators were replaced with “n/a” designators on summary worksheets.
- Every leap year includes entries for the 366th day.

6.2.4 Output National Oceanic and Atmospheric Administration-Processed Data Used for Present-Day Climate Conditions

Output DTN: SN0601PRECPTMP.002 consists of five workbooks (Table 6.2-1): four separate workbooks for NTS data, and one workbook for Amargosa Farms–Garey data. Workbooks for the NTS stations contain only a single worksheet with daily precipitation data. Data extracted from the Amargosa Farms–Garey station are presented in a single workbook consisting of three summary worksheets: one sheet for daily minimum temperature, one sheet for daily maximum temperature, and one sheet listing daily precipitation. The data are given in columnar form, one column per year. Each summary worksheet lists daily values by Julian day, with the site name, elevation, and UTM coordinates in the upper left-hand corner. Workbooks and summary worksheet names for each station are listed in Table 6.2-1.

Table 6.2-1. Summary Worksheets with Computed Parameters of Daily Values by Julian Day

Excel® Workbook File	Summary Worksheet	Units	Data Description and Timeframe Julian Day (J_day)
A12_97F.xls	Daily TTLppt	millimeters	Daily precipitation reported for J_day 60 of 1959 through J_day 365 of 1995; Daily precipitation reported for J_day 60 of 1997 through J_day 366 of 2004.
4JA_97G. xls	Daily TTLppt	millimeters	Daily precipitation reported for J_day 1 of 1959 through J_day 366 of 2004.
40MN_97F.xls	40MN_97	millimeters	Daily precipitation reported for J_day 1 of 1961 through J_day 366 of 2004.
Cane Springs_97F.xls	Cane Springs	millimeters	Daily precipitation reported for J_day 245 of 1964 through J_day 366 of 2004.
Amargosa Farms_97F.xls	Daily TTLppt	millimeters	Daily precipitation intermittently reported for J_day 335 of 1965 through J_day 212 of 1970; Large gaps of daily precipitation reports between J_day 212 of 1970 and J_day 365 of 1978; Daily precipitation for J_day 1 of 1979 through December 2004 with a few gaps.

Table 6.2-1. Summary Worksheets with Computed Parameters of Daily Values by Julian Day (Continued)

Excel® Workbook File	Summary Worksheet	Units	Data Description and Timeframe Julian Day (J_day)
Amargosa Farms_97F.xls (continued)	Daily MinTemp	degrees Celsius	Minimum temperature intermittently reported for J_day 335 of 1965 through J_day 212 of 1970; Large gaps of daily precipitation reports between J_day 212 of 1970 and J_day 365 of 1978; Minimum temperature reported for J_day 1, 1979, through December 2004 with a few gaps.
	Daily_MaxTemp	degrees Celsius	Maximum temperature intermittently reported for J_day 335 of 1965 through J_day 212 of 1970; Large gaps of daily precipitation reports between J_day 212 of 1970 and J_day 365 pf 1978; Maximum temperature reported for J_day 1 of 1979 through December 2004 with a few gaps.

Source: Output DTN: SN0601PRECPTMP.002.

6.2.5 Salient Points for Precipitation and Temperature

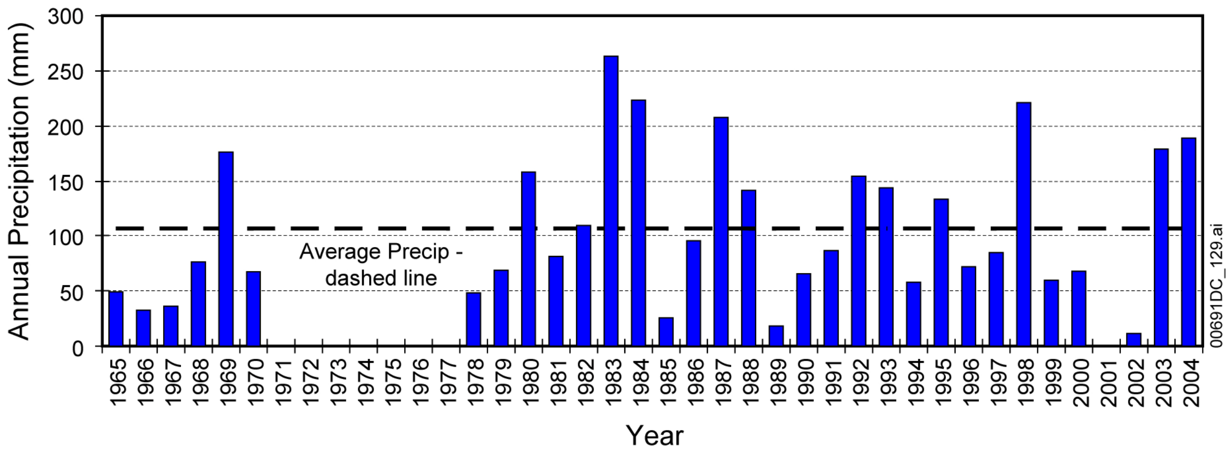
6.2.5.1 Precipitation

Presented in this section are scatter plots and bar plots of precipitation data for the locations Amargosa Farms–Garey, Area 12, Site 4JA, 40MN, and Cane Springs. For each of the five locations, four plots of precipitation data are presented.

The first plot is a bar plot of annual precipitation for each year; this plot also includes an average precipitation over the period of record. The second plot is a scatter plot illustrating daily precipitation; this scatter plot indicates the distribution of precipitation throughout the year. The third plot is a 15-day interval precipitation plot; the precipitation plot presents an average precipitation, calculated for each day of the year. The daily averages are grouped into 15-day intervals, and plotted on a bar graph. These 15-day interval plots show seasonal variability for precipitation. The fourth plot is a histogram of annual precipitation.

Amargosa Farms–Garey

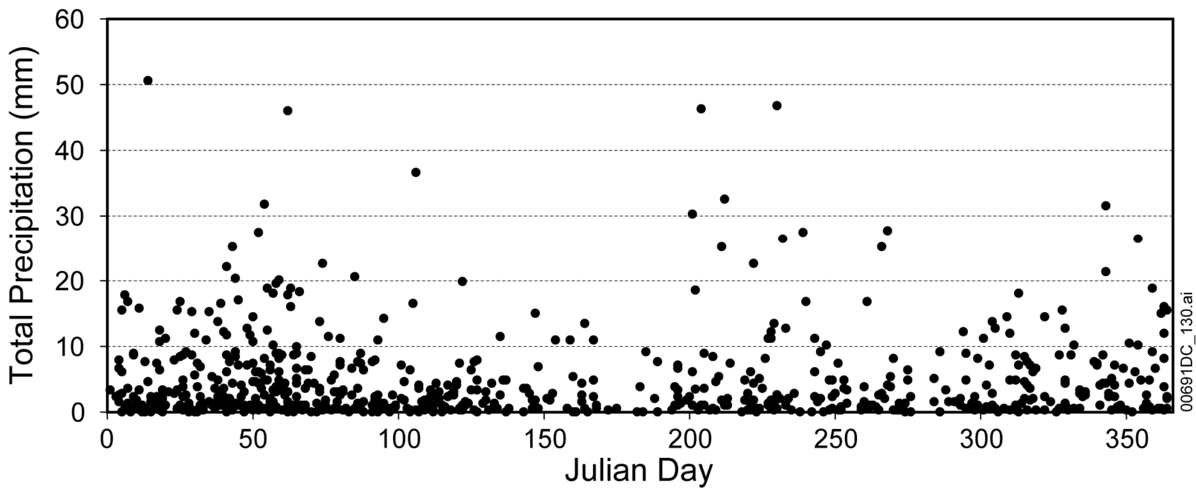
Annual precipitation for the period 1965 through 2004 is shown in Figure 6.2-1. At Amargosa Farms–Garey, the highest annual precipitation during the period was 263 mm, and occurred in 1983; the lowest annual precipitation was 11 mm, and occurred in 2002. For the 32 years of complete yearly record, the average annual precipitation is approximately 106 mm. From 1971 through 1977, inclusive, and throughout 2001, no precipitation data were available. Figures 6.2-2 and 6.2-3 indicate that two wet periods occurred: one from Julian day 1 through Julian day 75, and the other from Julian day 196 through Julian day 240. The precipitation histogram (Figure 6.2-4) indicates that most frequently (for 12 years, or 37% of the total), annual precipitation is between 50 and 100 mm. For seven of the 32 years (nearly 22% of the total), annual precipitation was 50 mm/yr or less. There were four years (or approximately 12% of the total) during which recorded precipitation exceeded 200 mm.



Source: See Appendix F.

NOTE: Data for the years 1971 through 1977, and for 2001, are not available. The dashed line indicates average precipitation over the period 1965 through 2004 (for available-data years).

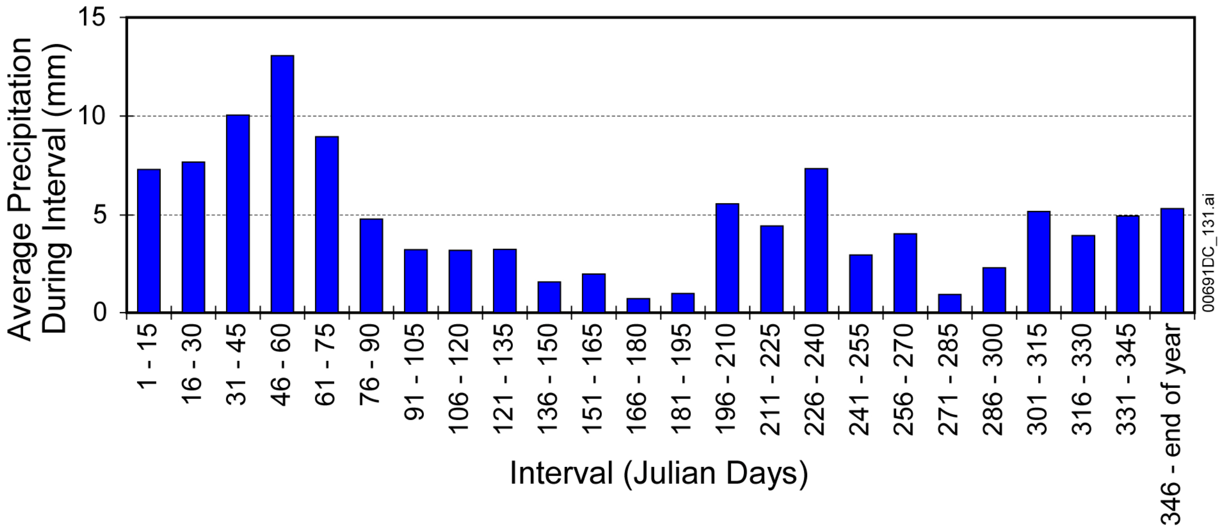
Figure 6.2-1. Annual and Period-of-Record Average of Precipitation at Amargosa Farms–Garey (1965 through 2004)



Source: See Appendix F.

NOTE: Data for the years 1971 through 1977, and for 2001, are not available.

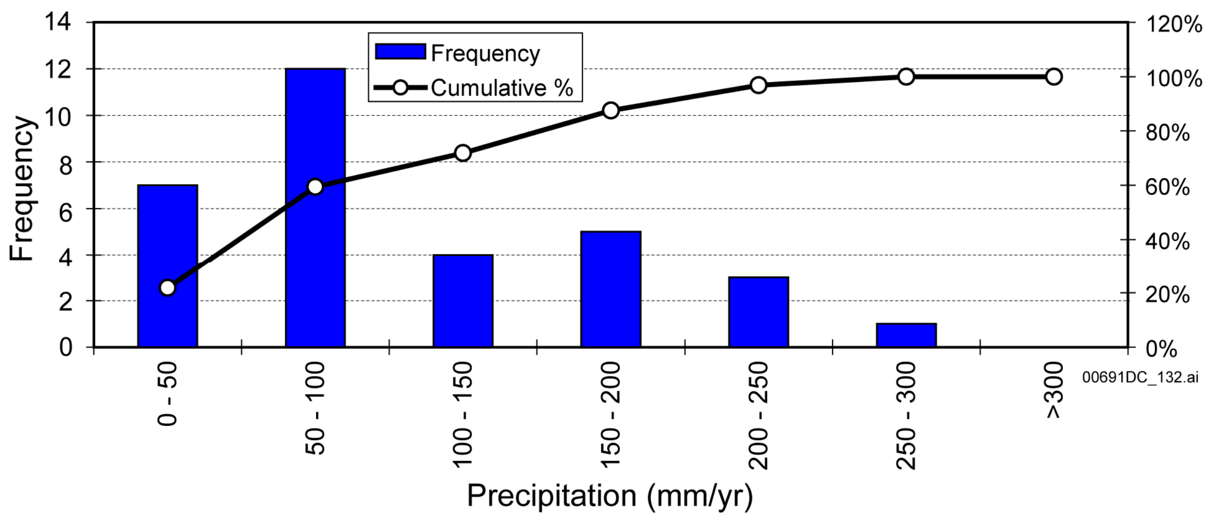
Figure 6.2-2. Daily Total Precipitation at Amargosa Farms–Garey (1965 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars. Data for the years 1971 through 1977, and for 2001, are not available.

Figure 6.2-3. Average Precipitation for 15-Day Intervals at Amargosa Farms–Garey (1965 through 2004)



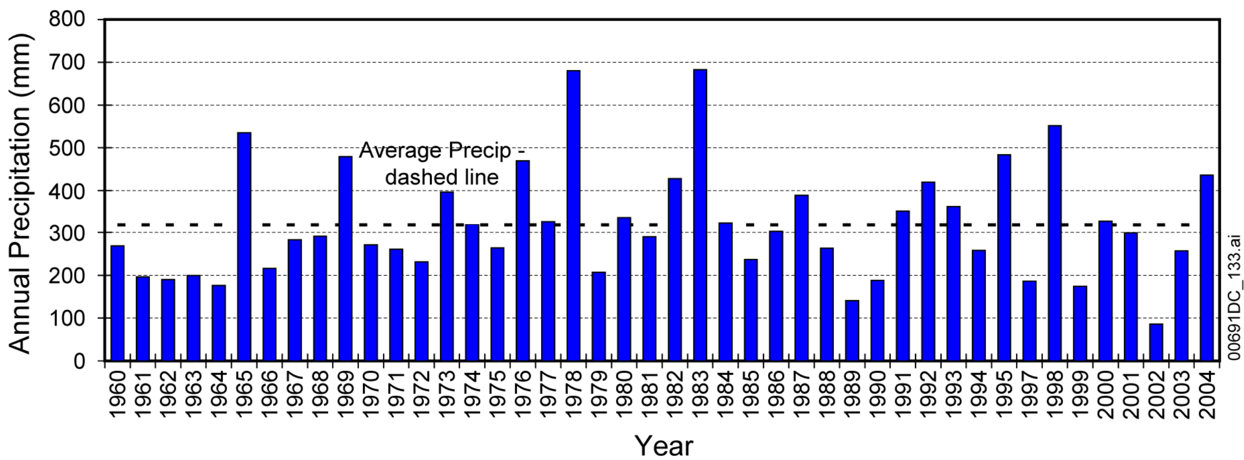
Source: See Appendix F.

NOTE: Data for the years 1971 through 1977, and for 2001, are no t available. Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.2-4. Frequency Distribution for Average Annual Precipitation at Amargosa Farms–Garey (1965 through 2004)

Area 12

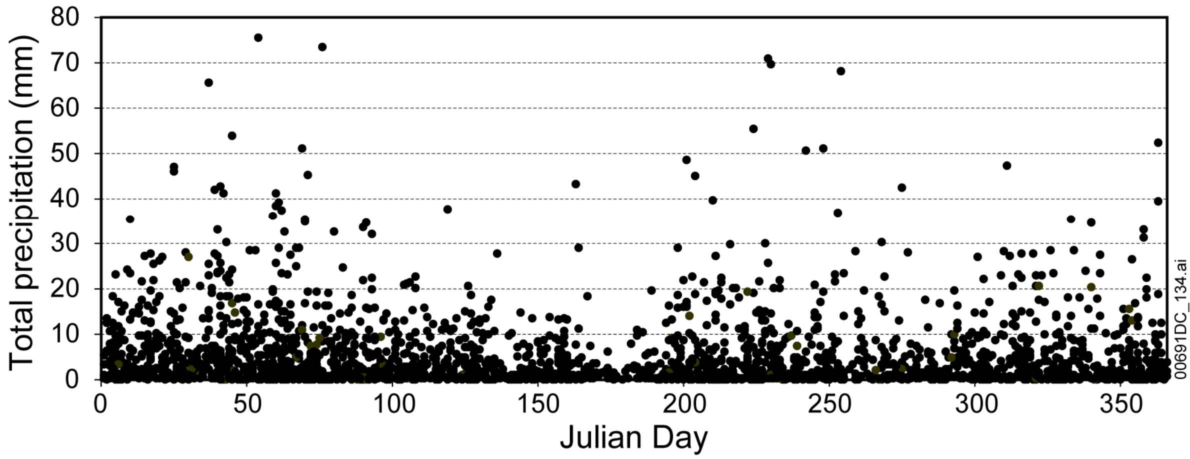
Annual precipitation recorded between 1960 through 2004 at Area 12 is shown on Figure 6.2-5. The highest annual precipitation was approximately 682 mm/yr, and occurred in 1983; the lowest was approximately 86 mm/yr, and occurred in 2002. The overall precipitation average from 1960 through 2004 was approximately 319 mm/yr. Figures 6.2-6 and 6.2-7 indicate that there were two wet periods: one from Julian day 1 through Julian day 90, and the other from approximately Julian day 196 through Julian day 255. The precipitation histogram (Figure 6.2-8) indicates that, in 64% of the years, precipitation was between 150 and 350 mm. For 11 of the 44 years of data, or 25% of the total, precipitation was between 250 and 300 mm, and for seven years (approximately 16% of the total), the precipitation was between 150 and 200 mm. During two of the 44 years (approximately 4% of the total), annual precipitation exceeded 650 mm. Precipitation was less than 100 mm in only one of the 44 years, and never less than 50 mm.



Source: See Appendix F.

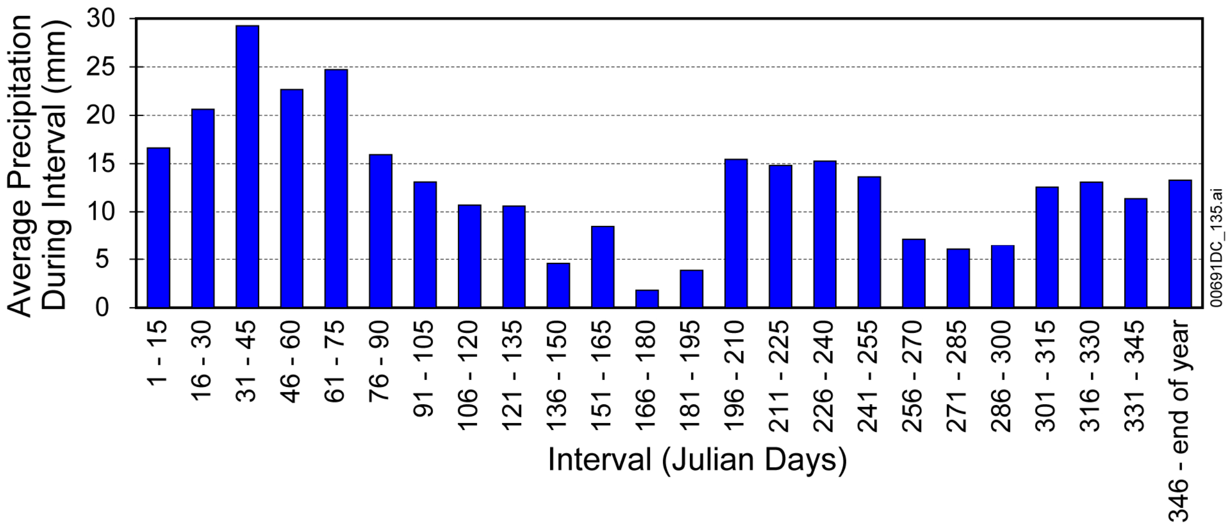
NOTE: The dashed line indicates average precipitation over the period-of-record (1960 through 2004).

Figure 6.2-5. Annual and Period-of-Record Average of Precipitation at Area 12 (1960 through 2004)



Source: See Appendix F.

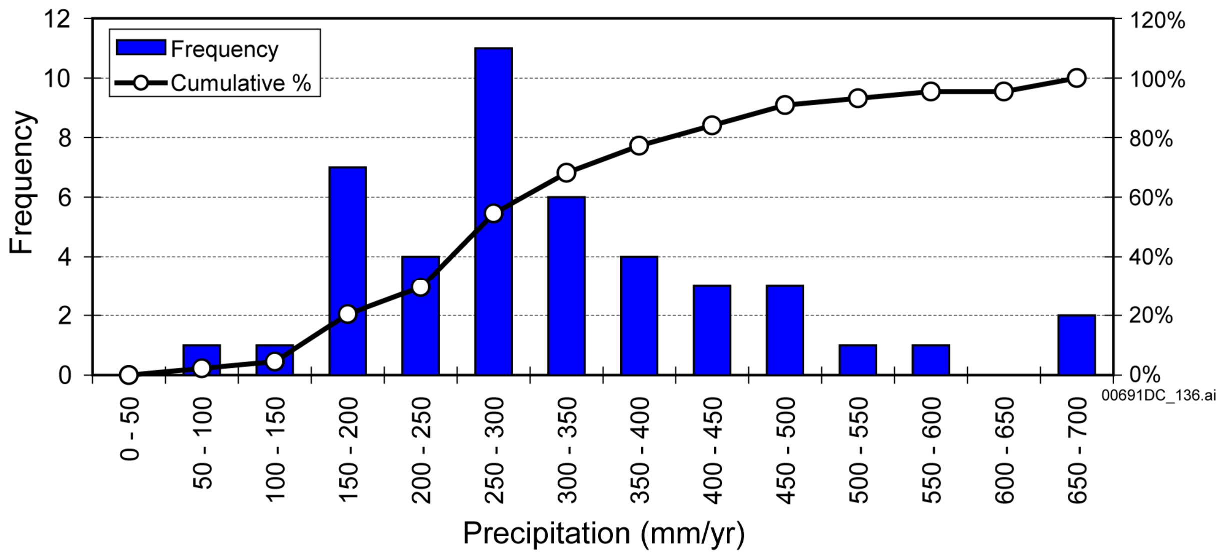
Figure 6.2-6. Daily Total Precipitation at Area 12 (1959 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.2-7. Average Precipitation for 15-Day Intervals at Area 12 (1960 through 2004)



Source: See Appendix F.

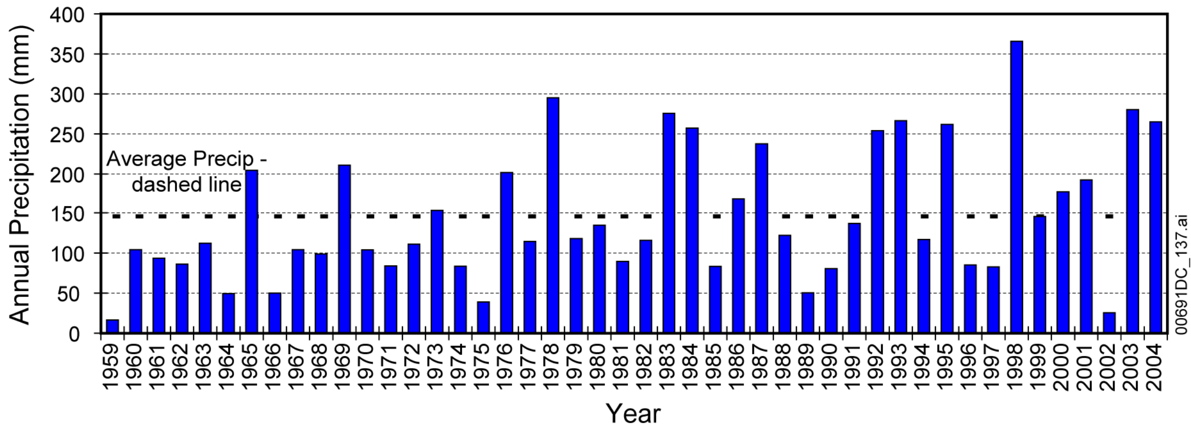
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.2-8. Frequency Distribution for Average Annual Precipitation at Area 12 (1960 through 2004)

Site 4JA

Annual precipitation recorded from 1959 through 2004 at Site 4JA is shown in Figure 6.2-9. During this 46-year period, the highest annual precipitation was approximately 366 mm, and occurred in 1998. The lowest annual precipitation was approximately 17 mm, and occurred in 1959. The overall average for this 46-year period was approximately 145 mm/yr.

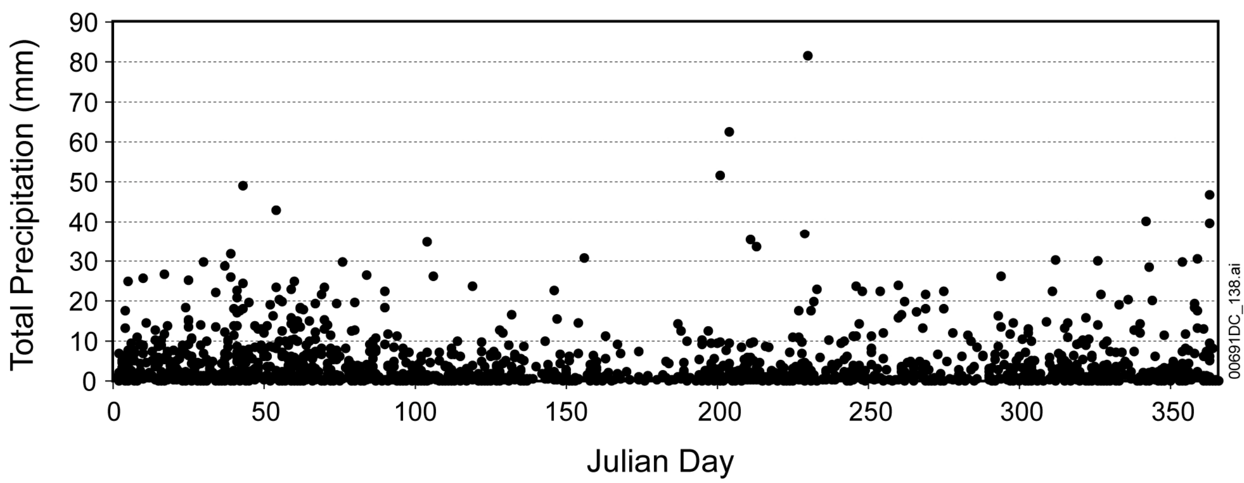
The scatter plot for daily precipitation is given in Figure 6.2-10. The average precipitation that occurs over a 15-day interval is plotted in Figure 6.2-11. The two figures indicate there were two wet periods: one from Julian day 30 through Julian day 75, and the other from approximately Julian day 196 through Julian day 255. The annual precipitation histogram given in Figure 6.2-12 indicates that, most frequently (for 13 of the 46 years, or approximately 28% of the total), the annual precipitation was between 100 and 150 mm. For 12 of the 46 years (or 26% of the total [a close second in frequency]), the annual precipitation was between 50 and 100 mm. Annual precipitation exceeded 350 mm/yr only once (less than 3% of the total) during the 46-year record.



Source: See Appendix F.

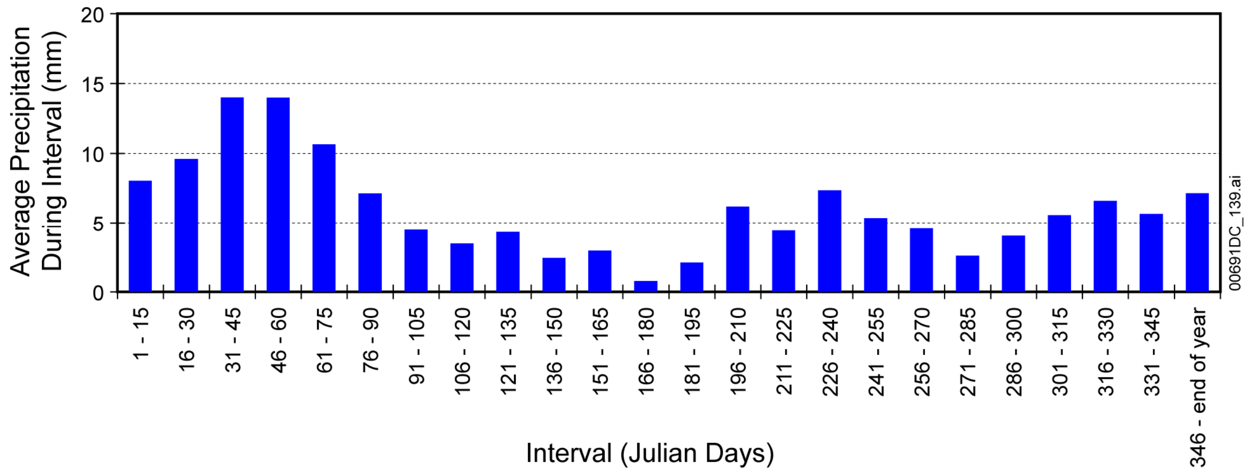
NOTE: The dashed line indicates average precipitation over the period-of-record 1959 through 2004.

Figure 6.2-9. Annual and Period-of-Record Average of Precipitation at Site 4JA (1959 through 2004)



Source: See Appendix F.

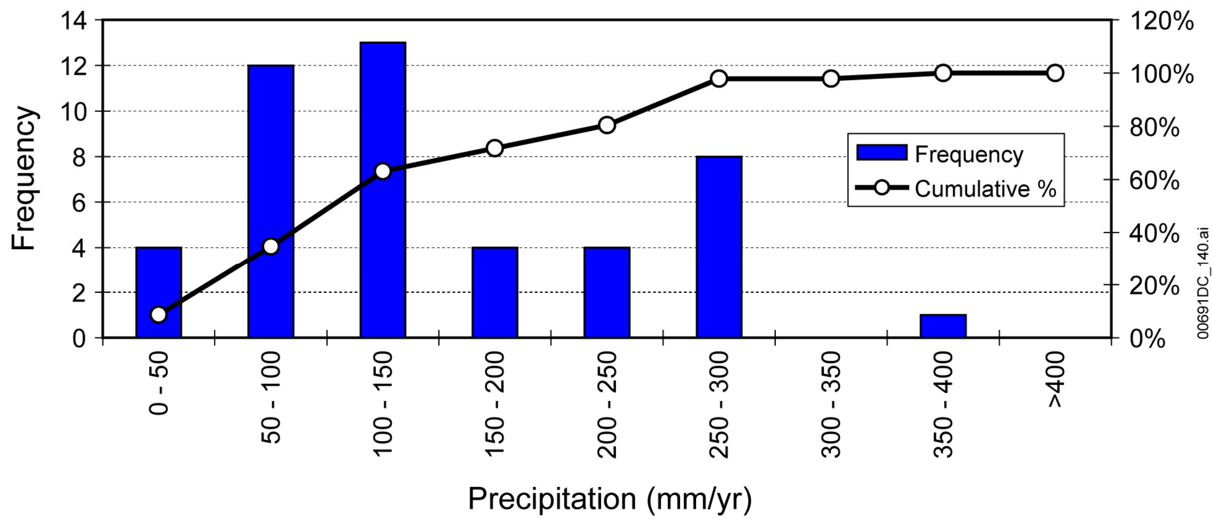
Figure 6.2-10. Daily Total Precipitation at Site 4JA (1959 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.2-11. Average Precipitation for 15-Day Intervals at Site 4JA (1959 through 2004)



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

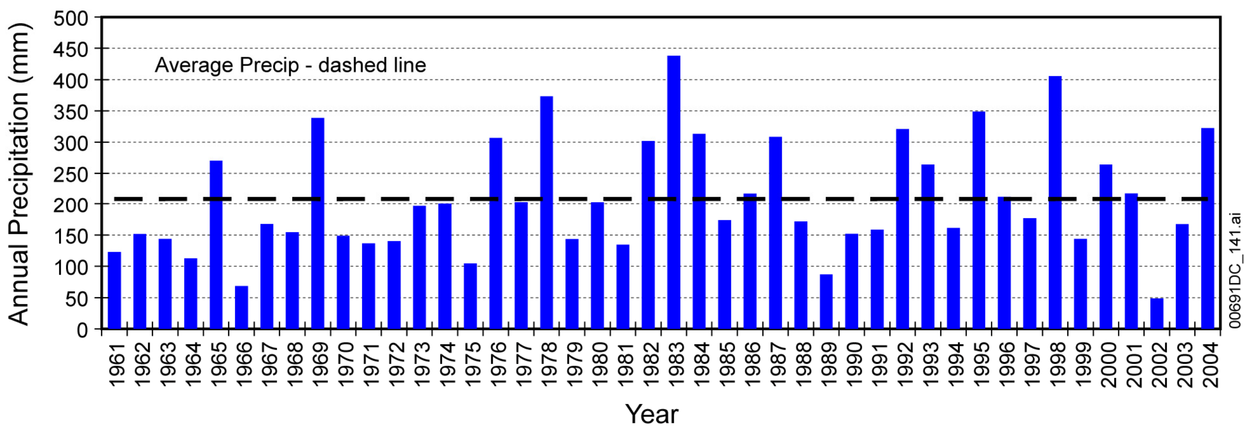
Figure 6.2-12. Frequency Distribution for Average-Annual Precipitation at Site 4JA (1959 through 2004)

<u>40MN</u>

Annual precipitation recorded from 1961 through 2004 at 40MN is shown in Figure 6.2-13. The highest annual precipitation during this 44-year period was approximately 438 mm, and occurred in 1983. The lowest annual precipitation was 49 mm, and occurred in 2002. The overall annual precipitation during the 44 years of record was approximately 209 mm.

The scatter plot for the daily total precipitation (given in Figure 6.2-14) and the 15-day precipitation interval bar plots (Figure 6.2-15) indicate that there were three wet periods: one from Julian day 30 through Julian day 90, the second from approximately Julian day 196 through Julian day 255, and the third starting at approximately Julian day 316 and tapering off slightly around the end of the year.

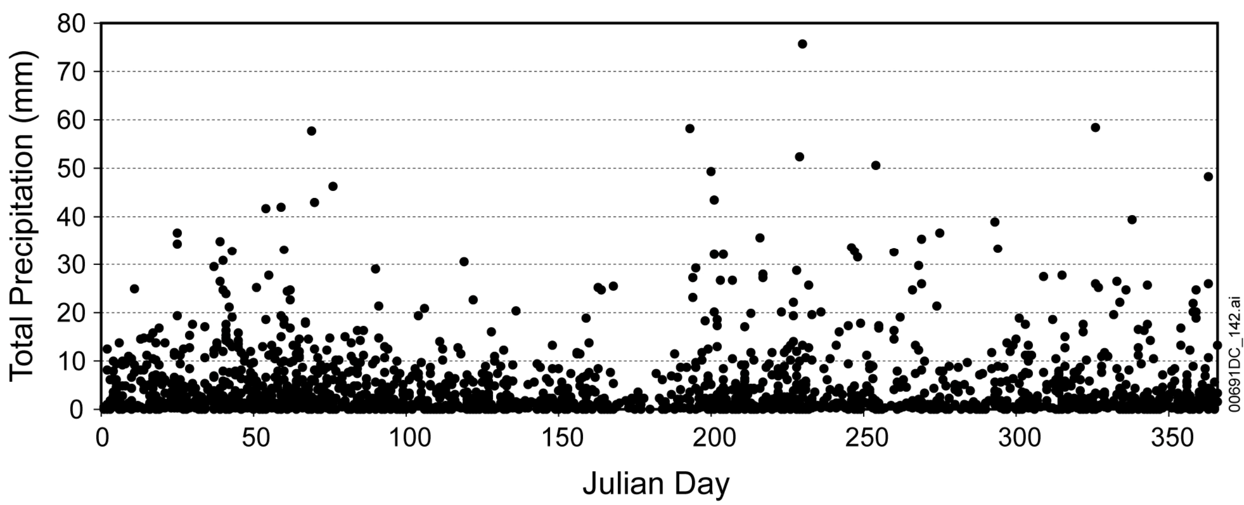
The precipitation histogram (Figure 6.2-16) indicates that, for 11 out of 44 years (or 25% of the total), precipitation was between 100 and 150 mm. Precipitation was less than 50 mm in only one year (slightly more than 2% of the total), and was greater than 400 mm in only two years (slightly less than 5% of the total).



Source: See Appendix F.

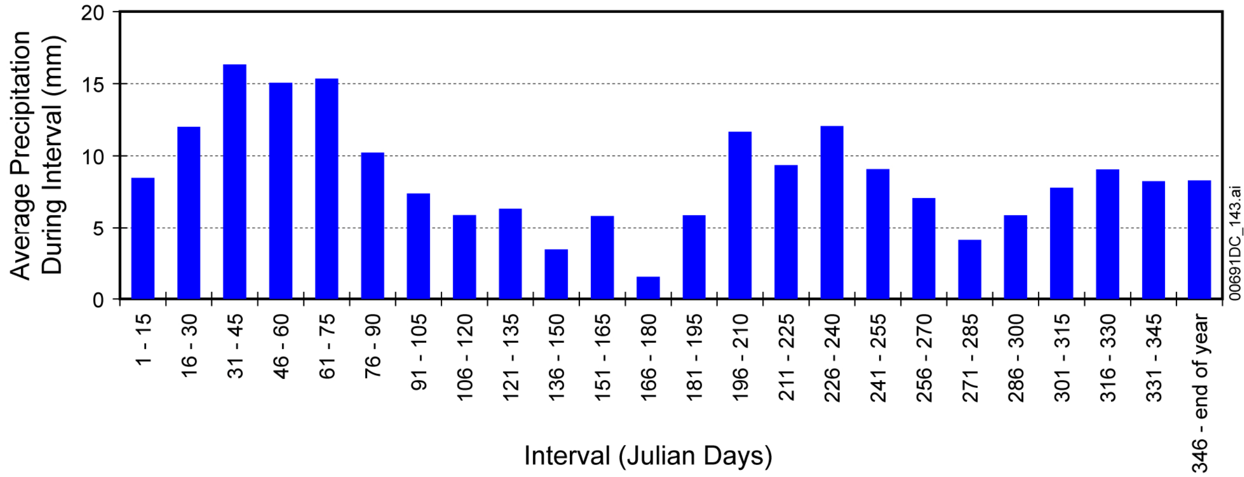
NOTE: The dashed line indicates average precipitation over the period-of-record 1961 through 2004.

Figure 6.2-13. Annual and Period-of-Record Average of Precipitation at 40MN (1961 through 2004)



Source: See Appendix F.

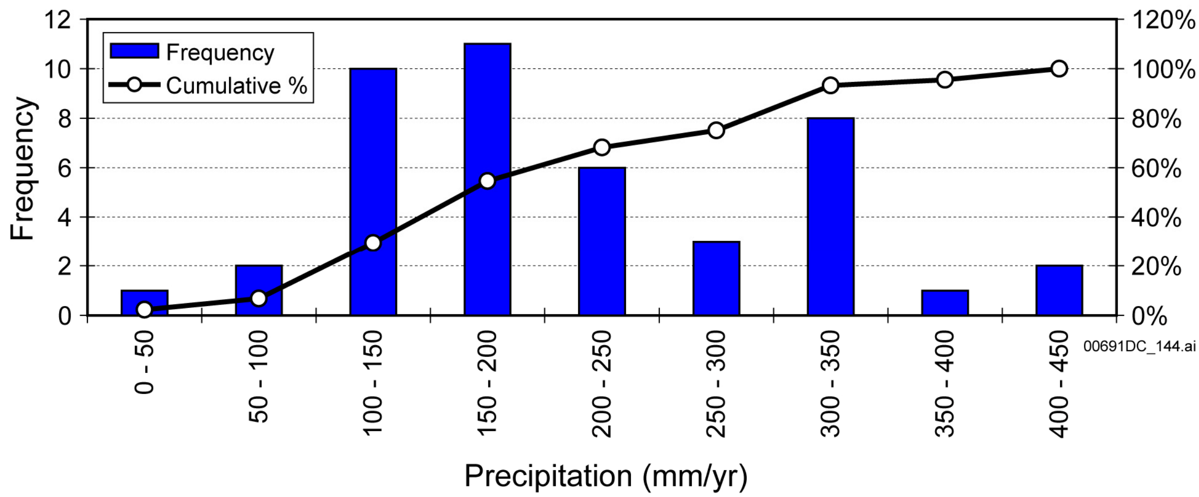
Figure 6.2-14. Daily Total Precipitation at 40MN (1961 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by a factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.2-15. Average Precipitation for 15-Day Intervals at 40MN (1961 through 2004)



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

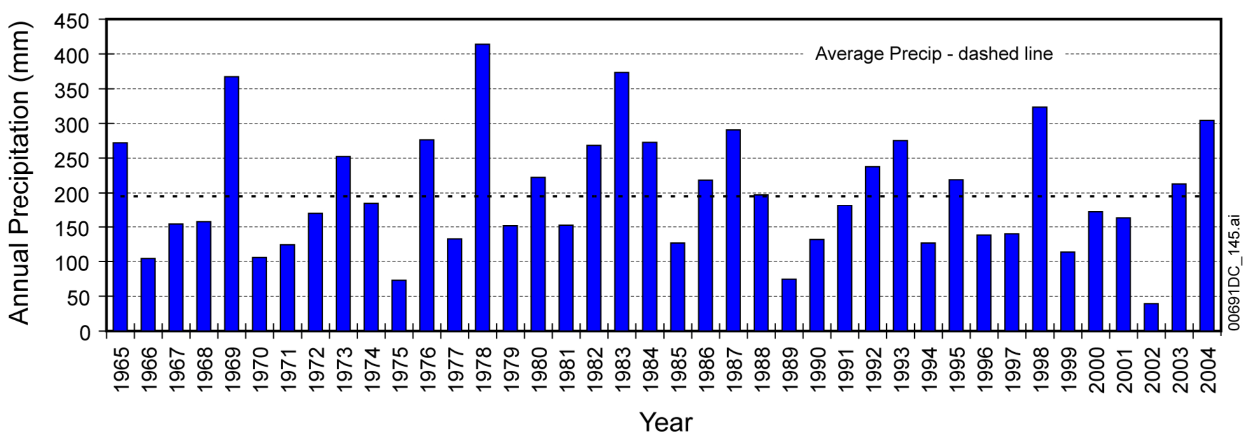
Figure 6.2-16. Frequency Distribution for Average Annual Precipitation at 40MN (1961 through 2004)

Cane Springs

Annual precipitation recorded from the period 1965 through 2004 at Cane Springs is shown on Figure 6.2-17. During the 40 years of recorded data, the highest annual precipitation was approximately 414 mm, and occurred in 1978. The lowest annual precipitation was approximately 40 mm, and occurred in 2002. For the 40-year time period, the precipitation average is approximately 195 mm.

The daily total precipitation scatter plot (Figure 6.2-18) and the 15-day interval precipitation bar plot (Figure 6.2-19) indicate that the most precipitation generally occurs between Julian day 1 and Julian day 75. Precipitation days quickly decrease, transitioning into a very dry period from approximately Julian day 166 through Julian day 180. Another wet period occurs from Julian day 196 through Julian day 255, and is followed by a period during which there are few precipitation events. Precipitation starts to increase around Julian day 286. A third wet period occurs between Julian day 316 and lasts through the end of the year.

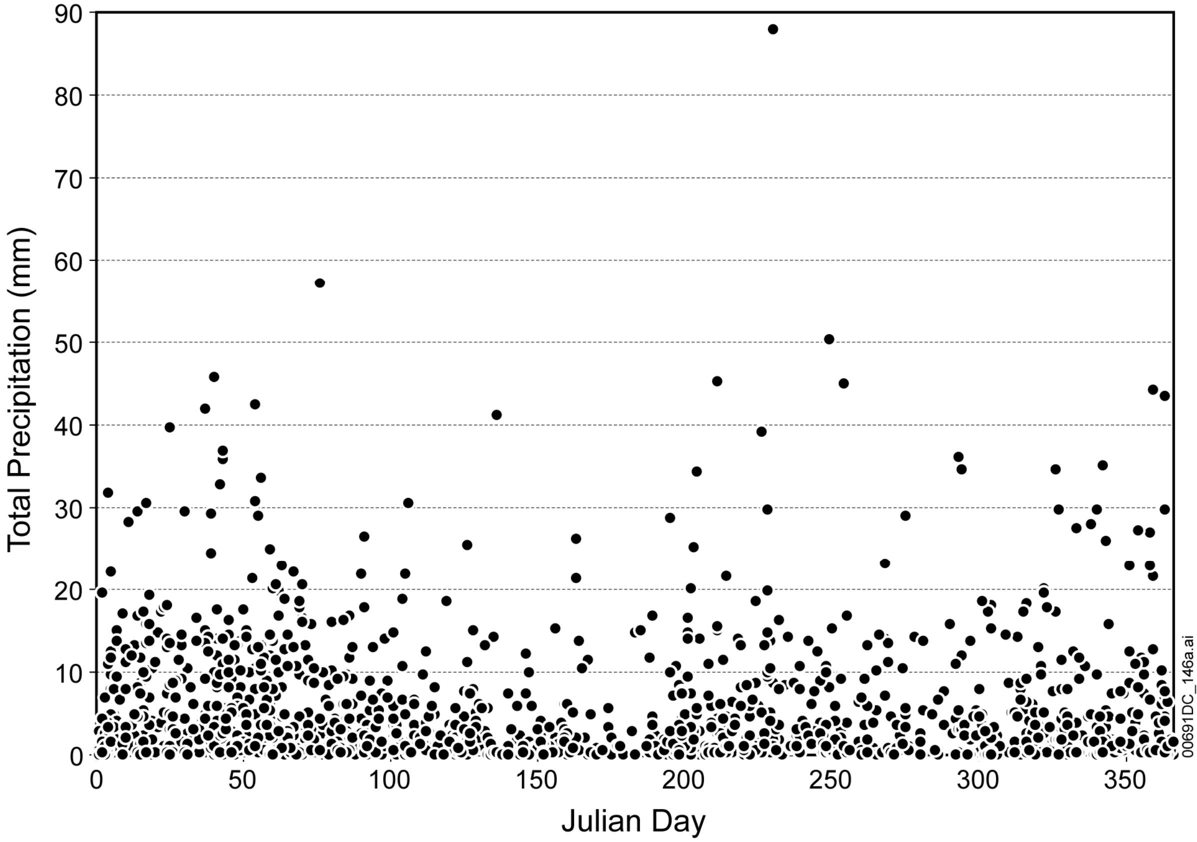
A histogram of annual precipitation is given in Figure 6.2-20. Of the 40 years of recorded precipitation data, there is an equal number of years (10 years each) during which annual precipitation is either between 100 and 150 mm/yr or between 150 to 200 mm/yr (i.e., there are 20 years [50% of the total] during which annual precipitation was between 100 and 200 mm/yr). Of the 40 years of record, there is only one year during which annual precipitation was higher than 400 mm, and one year during which annual precipitation was lower than 50 mm, each representing approximately 2% of the total.



Source: See Appendix F.

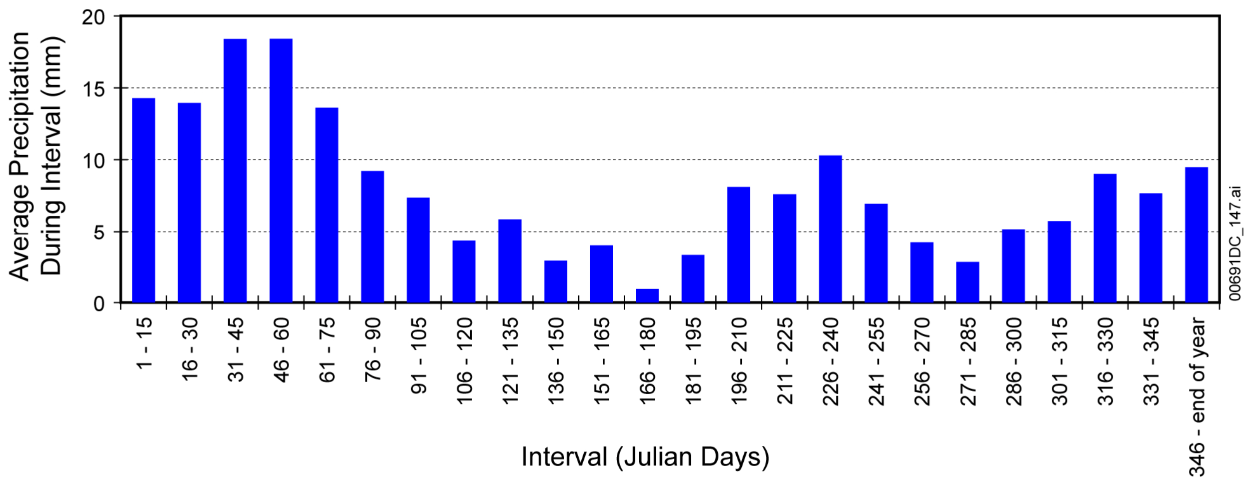
NOTE: The dashed line indicates average precipitation over the period-of-record 1965 through 2004.

Figure 6.2-17. Annual and Period-of-Record Average of Precipitation at Cane Springs (1965 through 2004)



Source: See Appendix F.

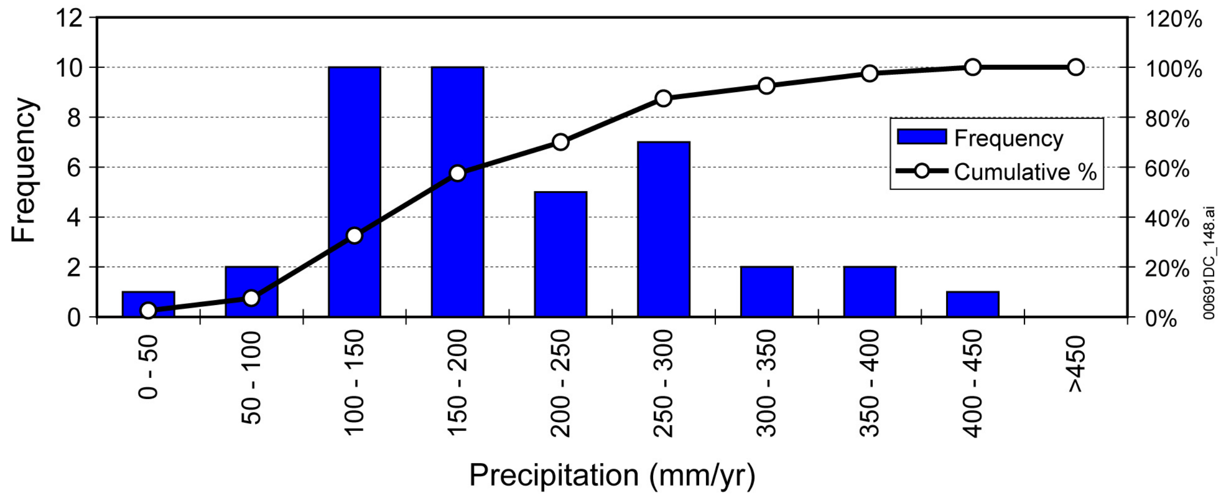
Figure 6.2-18. Daily Total Precipitation at Cane Springs (1964 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.2-19. Average Precipitation for 15-Day Intervals at Cane Springs (1965 through 2004)



Source: See Appendix F.

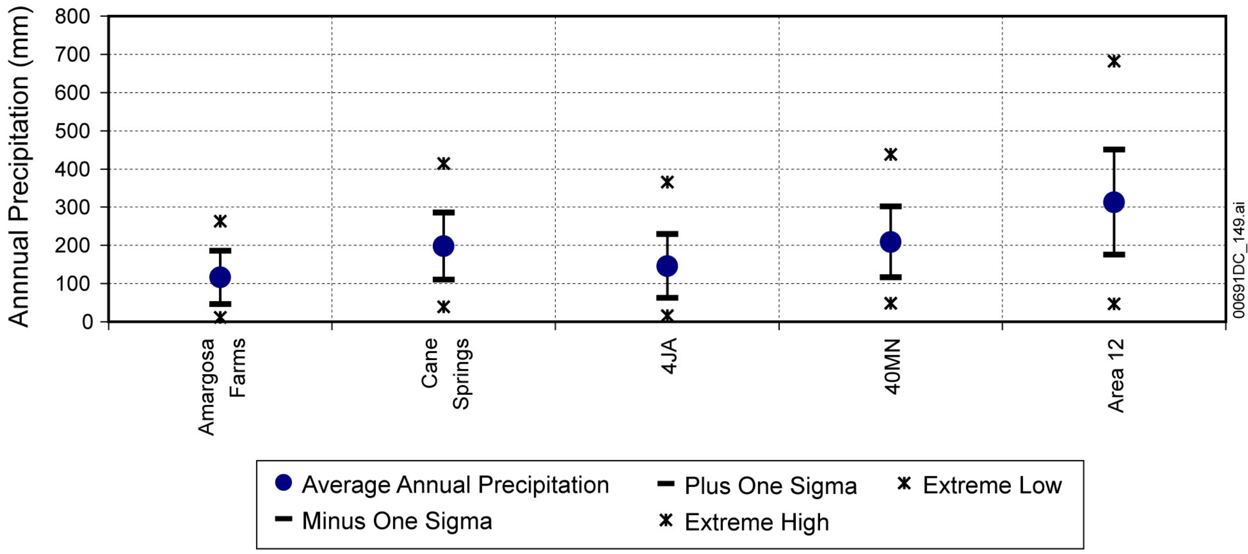
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.2-20. Frequency Distribution for Average Annual Precipitation at Cane Springs (1965 through 2004)

Summary of Precipitation Trends Seen at the Five Stations

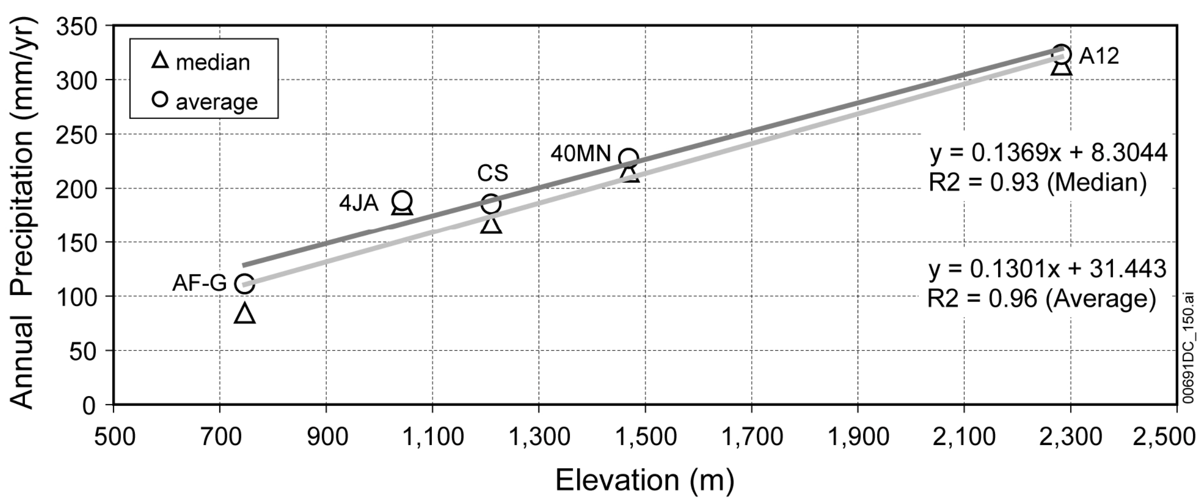
A plot of the average precipitation recorded at each of the five sites, and one standard deviation above and below that average, are given in Figure 6.2-21. The plots in Figure 6.2-21 indicate that Area 12 has the highest average annual precipitation and highest extreme value. Area 12 also has the largest variability for annual precipitation. The lowest average annual precipitation is at Amargosa Farms–Garey, which also has the lowest variability for precipitation.

Plotting average and median annual precipitation values against elevation reveals a strong correlation between the two, which is illustrated in Figure 6.2-22. Amargosa Farms–Garey, the lowest in elevation (747 m amsl), has the lowest annual average precipitation; Area 12, the highest in elevation (2,283 m amsl), has the highest average annual precipitation.



Source: See Appendix F.

Figure 6.2-21. Average Annual Precipitation Plus and Minus One Standard Deviation (One Sigma) and Extreme High and Low Precipitation Values

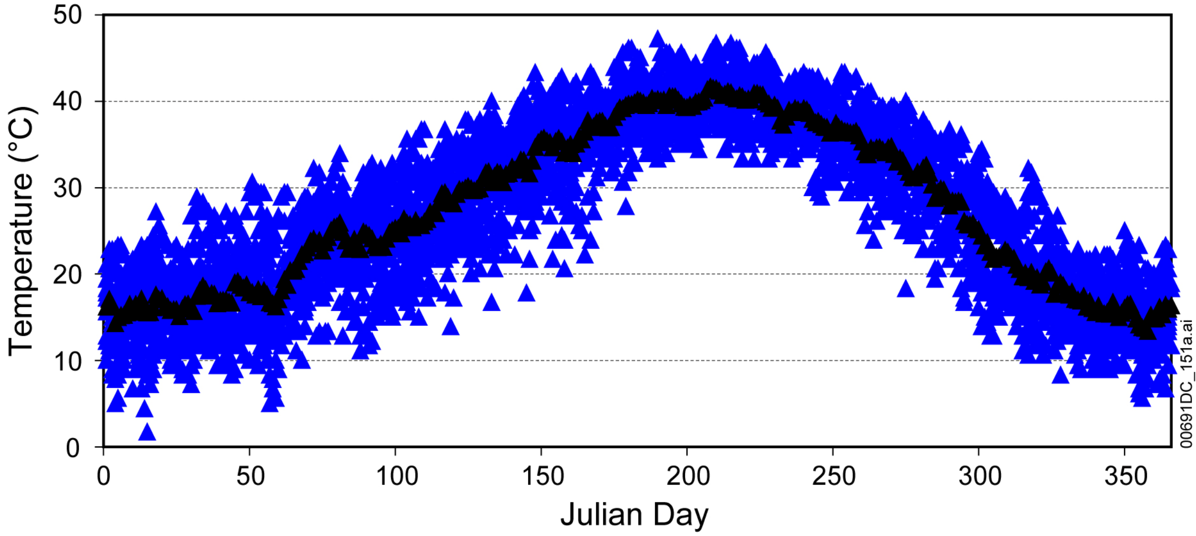


Source: See Appendix F.

Figure 6.2-22. Average and Median Annual Precipitation with Respect to Elevation for Amargosa Farms–Garey, Area 12, Site 4JA, 40MN, and Cane Springs

6.2.5.2. Temperature

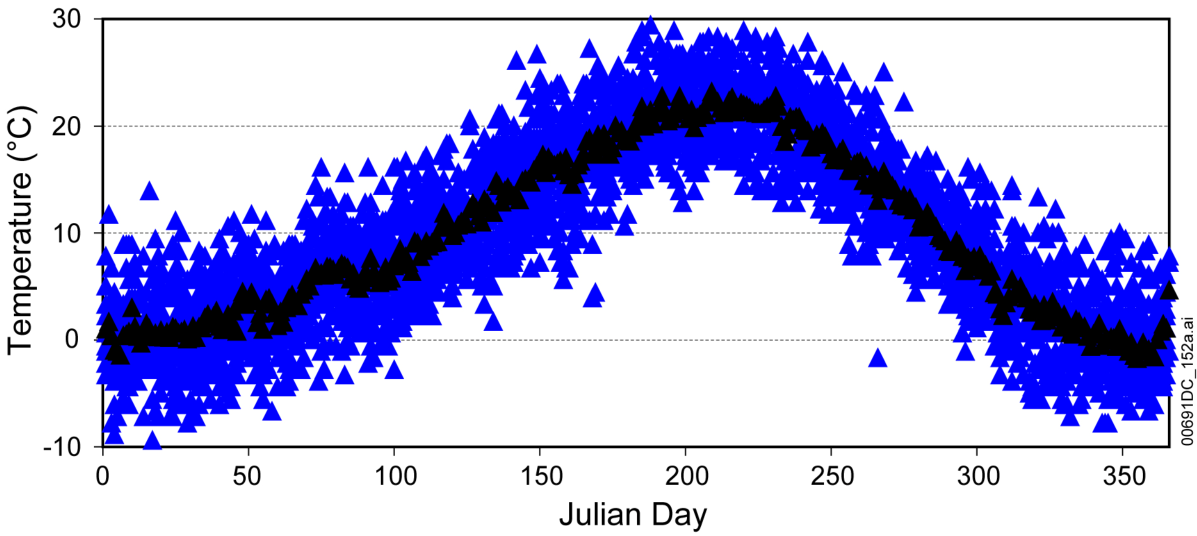
Figure 6.2-23 is a scatter plot of maximum temperature, and Figure 6.2-24 is a scatter plot of minimum temperature. Both figures also include daily average values.



Source: See Appendix F.

NOTE: The black symbols denote an average maximum daily temperature for the reference period.

Figure 6.2-23. Maximum Daily Temperatures and the Average Daily Maximum Temperature for Amargosa Farms–Garey (1993 through 2004)

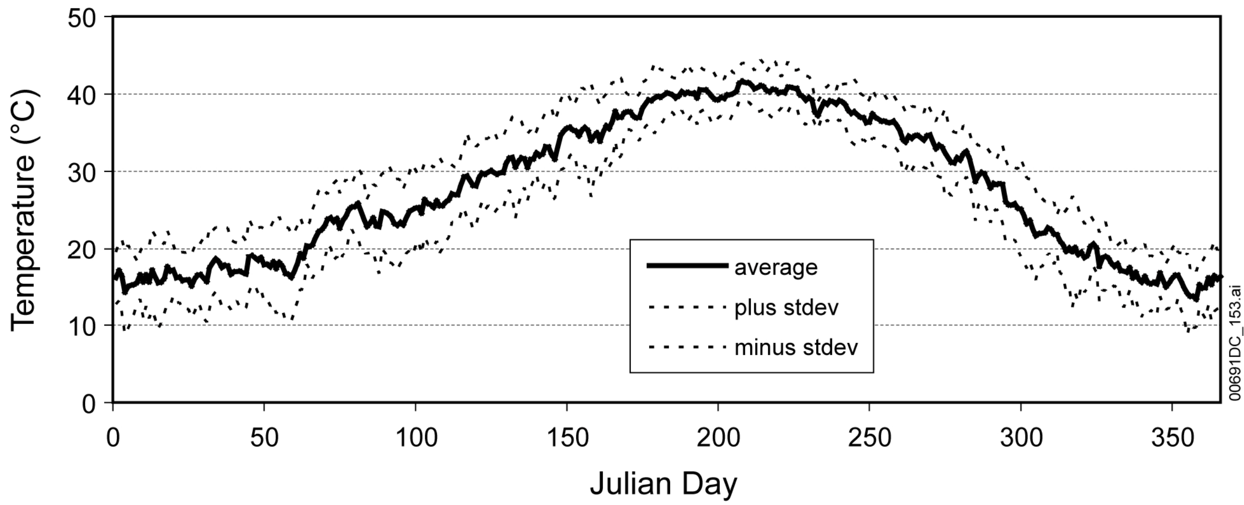


Source: See Appendix F.

NOTE: The black symbols denote an average minimum daily temperature for the reference period.

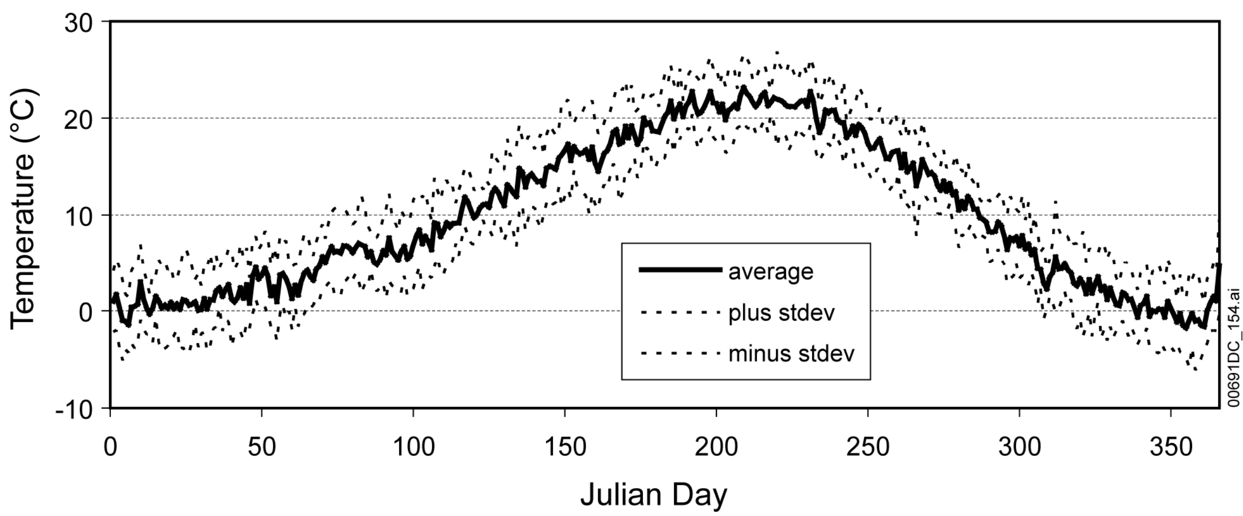
Figure 6.2-24. Minimum Daily Temperatures and the Average Daily Minimum Temperature for Amargosa Farms–Garey (1993 through 2004)

The average minimum and average maximum daily temperatures, plus and minus one standard deviation, have been plotted in Figures 6.2-25 and 6.2-26 to identify patterns and trends for minimum and maximum daily temperatures.



Source: See Appendix F.

Figure 6.2-25. Average Daily Maximum Temperature, Plus and Minus One Standard Deviation, Recorded at Amargosa Farms–Garey (1993 through 2004)



Source: See Appendix F.

Figure 6.2-26. Average Daily Minimum Temperature, Plus and Minus One Standard Deviation, Recorded at Amargosa Farms–Garey (1993 through 2004)

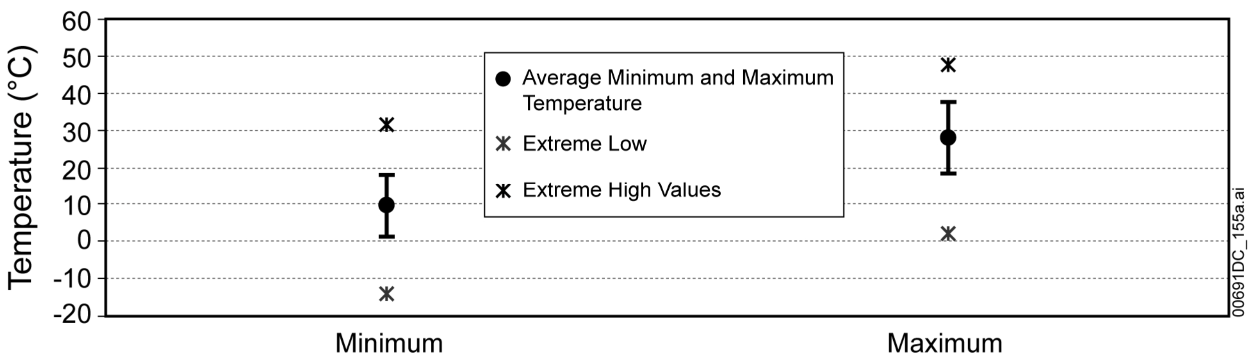
Similar to what is seen at the YM sites, maximum and minimum temperature values recorded at Amargosa Farms–Garey have periods during which temperature values remain fairly constant, noted in this document as two temperature plateaus. One plateau occurs during the coldest winter days of the year, and the other occurs during the hottest days.

The low-temperature plateau starts around Julian day 358 and continues until approximately Julian day 60, lasting approximately 65 to 68 days.

The high-temperature plateau starts around Julian day 180 and continues until around Julian day 226. This high-temperature plateau lasts for approximately 45 to 48 days.

The time periods during which temperature values gradually transition between the high and low plateaus (i.e., the spring and fall days) are not equal. The spring season, during which temperatures progressively increase, lasts approximately 85 to 90 days. Spring starts around Julian day 97, and continues until approximately Julian day 180.

Temperature values begin to progressively decrease around Julian day 227, noted in this document as the beginning of fall. The progressive decline in temperature ceases around Julian day 358. Falling temperature values (fall) last approximately 132 to 135 days. A plot of the Amargosa Farms–Garey average minimum and maximum daily temperature values, plus and minus one standard deviation, and extreme values, is shown in Figure 6.2-27.



Source: See Appendix F.

Figure 6.2-27. Average Minimum, Average Maximum Temperature Values and Extreme High and Extreme High Low Average Values Recorded at Amargosa Farms–Garey (1965 through 2004)

6.3 METEOROLOGICAL DATA EXTRACTION FROM FUTURE PROXY METEOROLOGICAL STATIONS

Seven sites in the western half of the conterminous United States were recommended in *Future Climate Analysis* (BSC 2004 [DIRS 170002]) as representative of projected precipitation and temperature ranges likely to occur in the vicinity of Yucca Mountain during the next monsoon and glacial-transition climate cycle. These locations are denoted as future proxy climate sites. Of these seven sites, three are in the State of Washington (Rosalia, St. John, and Spokane); the other four locations are: Delta, Utah; Hobbs, New Mexico; Beowawe, Nevada; and Nogales, Arizona. Data were downloaded from NOAA meteorological stations at these locations for input to DTN: SN0512NOAADATA.003 [DIRS 176100].

NOAA meteorological stations are classified as COOP (cooperative) stations and/or Weather Bureau, Air Force, and Navy (WBAN) stations. The COOP stations are part of the National Weather Service Cooperative Station Network. The WBAN stations are those that were given identifying numbers, in the 1950s, in order to develop a coordinated station numbering scheme acceptable to several distinct weather-reporting authorities. Currently, both COOP and WBAN stations are monitored by the National Climatic Data Center.

It should be noted that a few of the recommended future proxy climate sites have NOAA meteorological stations that, during the time period addressed by this analysis, have either been moved or have had more than one station in operation. For these cases, the specific meteorological stations selected for data extraction were those that had the most complete data sets, and had been in operation for the longest time periods.

The data sets in DTN: SN0512NOAADATA.003 [DIRS 176100] are formatted as ASCII text files. Table 6.3-1 lists NOAA station locations, their COOP or WBAN identification numbers, and the (text) file names of the files that contains the corresponding downloaded meteorological data in DTN: SN0512NOAADATA.003 [DIRS 176100]. This DTN includes **inv.txt* files for each **dat.txt* file that includes the station name, the associated COOP and/or WBAN identification number, the meteorological data included (for that year) in the **dat.txt* file (denoted as "element" in the file), and the year and number of months for which the meteorological data were collected.

The downloaded temperature and precipitation data in DTN: SN0512NOAADATA.003 [DIRS 176100] were reformatted and used as input for output DTN: SN0603DWEATHER.002. The intended use of this output DTN is as input in predicting likely precipitation and temperature values characteristic of future climate conditions within the vicinity of Yucca Mountain, in the analysis of temperature and precipitation for future climates in the Yucca Mountain vicinity. Output DTN: SN0603DWEATHER.002 contains daily minimum and maximum temperature data and precipitation data for each meteorological station.

Table 6.3-1. Files Used to Extract Precipitation and Temperature Data for Each Location

Site	NOAA Station ID Number	File Name
Beowawe, Nevada	COOP 260795	*896109725272dat.txt*
Delta, Utah	COOP 422090	*833900726569dat.txt*
Hobbs, New Mexico	COOP 294026	*64086727775dat.txt*
Nogales, Arizona	COOP 025921	*721532727755dat.txt*
Rosalia, Washington	COOP 457180	*195364725137dat.txt*
Spokane, Washington	COOP 457938 WBAN 24157[a]	*906143725006dat.txt*
St. John, Washington	COOP 457267	*978568725270dat.txt*

Source: DTN: SN0512NOAADATA.003 [DIRS 176100].

[a] Spokane, Washington, has both a WBAN and a COOP number.

ID = identification; NOAA = National Oceanic and Atmospheric Administration.

6.3.1 Data Extraction

The intended use of output DTN: SN0603DWEATHER.002 is for generating a suite of temperature and precipitation inputs representative of future climate within the vicinity of Yucca Mountain in the next 10,000 years. Therefore, it is necessary to have precipitation data for every day of a yearly cycle. Consequently, data from years containing only temperature and precipitation data for a 365-day (or 366-day) cycle (i.e., no “n/a” days) were used as input to generate output DTN: SN0603DWEATHER.002. The process for such data extraction is described in Section 6.3.2.

6.3.2 Data Processing

NOAA data sets in DTN: SN0512NOAADATA.003 [DIRS 176100] are very large, and use an unusual and hard-to-read ASCII format structure. The data-transmission format that NOAA adopted makes it is difficult to use common data manipulation tools such as Excel®. Additionally, the transmitted data files include days during which no meteorological data were recorded (because instruments were off-line, or there were data acquisition and/or transmission errors). For ease of use, analysis, and interpretation, meteorological data in DTN: SN0512NOAADATA.003 [DIRS 176100] were therefore reformatted using Mathcad®, then exported from Mathcad® to Excel®. The following activities were conducted to reformat the temperature and precipitation data into easily readable, tabular Excel® files:

- Extract precipitation and temperature values from the source file
- Remove any erroneous values from the source data sets
- Convert precipitation from hundredths of an inch to millimeters
- Convert temperatures from degrees Fahrenheit to degrees Celsius
- Identify 365- (or 366-) day cycles (with each cycle starting every March 1) that include complete data sets (defined as those data sets that have no erroneous or missing values for precipitation and temperature data)
- Extract complete precipitation and temperature data sets, and reformat into easily read columnar structure
- Export the reformatted and screened data to easily readable Excel® workbooks.

The extraction routines are organized into three Mathcad® files; the names and functions of these files are described in Table 6.3-2, and the Mathcad® functions are given in Appendix C.

For each parameter of PRCP (precipitation), TMIN (minimum temperature), and TMAX (maximum temperature), a four-column matrix is generated (holding numerical values for the years, months, days, and parameter values). Next, erroneous data designated with “−9999”, “9999,” or “-” (a dash) are filtered out with the routine *Filter()*. After any error flags are filtered from the data, TMIN and TMAX values are converted from degrees Fahrenheit to degrees Celsius, and precipitation is converted from hundredths of an inch to millimeters. The three resulting matrices of PRCP, TMIN, and TMAX are then combined and saved in an Excel® worksheet component in Mathcad®, where an integer date is calculated from the Excel® function DATE() and shifted to equal 1 on January 1 of the first year of the data. This Excel® worksheet is exported as a separate Excel® file (Appendix B).

Table 6.3-2. Files Used to Extract Precipitation and Temperature Data for “Complete” Years

File Name	Routine
GT_Climate_Data_1-10-2006.xmcd	Extracts data for glacial transition climate proxy sites: Beowawe, Nevada; Delta, Utah; and Rosalia, Spokane, and St. John, Washington
Monsoon_Climate_Data_1-10-2006.xmcd	Extracts data for monsoon climate proxy sites: Hobbs, New Mexico, and Nogales, Arizona
Future_Climate_Routines_1-10-2006.xmcd	Holds routines referenced in previous two files: read_climate_data1() read_climate_data2() (For Spokane only) Filter() CompleteYearPrecip(PRCP)

Source: Output DTN: SN0603DWEATHER.002.

Functions in *GT_Climate_Data_1-10-2006.xmcd* and *Monsoon_Climate_Data_1-10-2006.xmcd* make reference to routines in *Future_Climate_Routines_1-10-2006.xmcd* (output DTN: SN0603DWEATHER.002). The first step in the data-reformatting process (Figure 6.3-1) is to read the raw source-file data (by using Mathcad® from the source files), then extract daily values of PRCP, TMIN, and TMAX through the routine read_climate_data1() for all proxy sites, with the exception of Spokane, Washington, which uses the routine read_climate_data2().

Next, the shifted integer dates are added to the three data matrices. The daily precipitation data are separated and saved in a table through the routine CompletYearPrecip(PRCP). This routine arranges daily precipitation values into columns of complete years (beginning with March 1 and ending with February 28 or 29 of the following year). Row 1 lists the year of the March 1 start day; row 2 lists precipitation on the day preceding March 1 (either February 28 or 29); rows 3 to 367 or 368 list the precipitation amounts, in millimeters, for each day from March 1 to February 28.

The final precipitation-table file is saved to an Excel® worksheet component in Mathcad®, and is exported as a separate Excel® file. Figure 6.3-1 shows the extraction process in flowchart format (using the Beowawe, Nevada, data as an example).

6.3.3 Internal Checking

An internal check was performed of the Mathcad® files that were used to extract data from the source files. The first step taken to accomplish this was verification that source data were fed correctly into two main files, *GT_Climate_Data_1-10-2006.xmcd* and *Monsoon_Climate_Data_1-10-2006.xmcd* (output DTN: SN0603DWEATHER.002). This check was performed by viewing the data matrices in the Mathcad® files, and comparing the values to those in the raw data files. Next, the Mathcad® functions and routines were checked by viewing the matrices from the data path (Figure 6.3-1) for Beowawe, Nevada, for Spokane, Washington, and for Hobbs, New Mexico (output DTN: SN0603DWEATHER.002).

The remaining proxy site functions were then checked against the functions used for Beowawe, Spokane, and Hobbs, to ensure the same functions were being used for all proxy sites.

In addition, daily output values from the two Excel® workbooks, (proxy site)*_Precipitation.xls* and (proxy site)*_Tmin_Tmax_PPT.xls* (where "proxy site" is one of the proxy climate sites; parentheses are not included in the file name) of output DTN: SN0603DWEATHER.002 were compared against the original source files for Beowawe, Spokane, and Hobbs. This step was performed by comparing data values for a given date against data for the same date in the source file. The internal check has proved that the data extraction and table development are appropriate and transparent.

6.3.4 Output Data Files Used for Future Proxy Climates

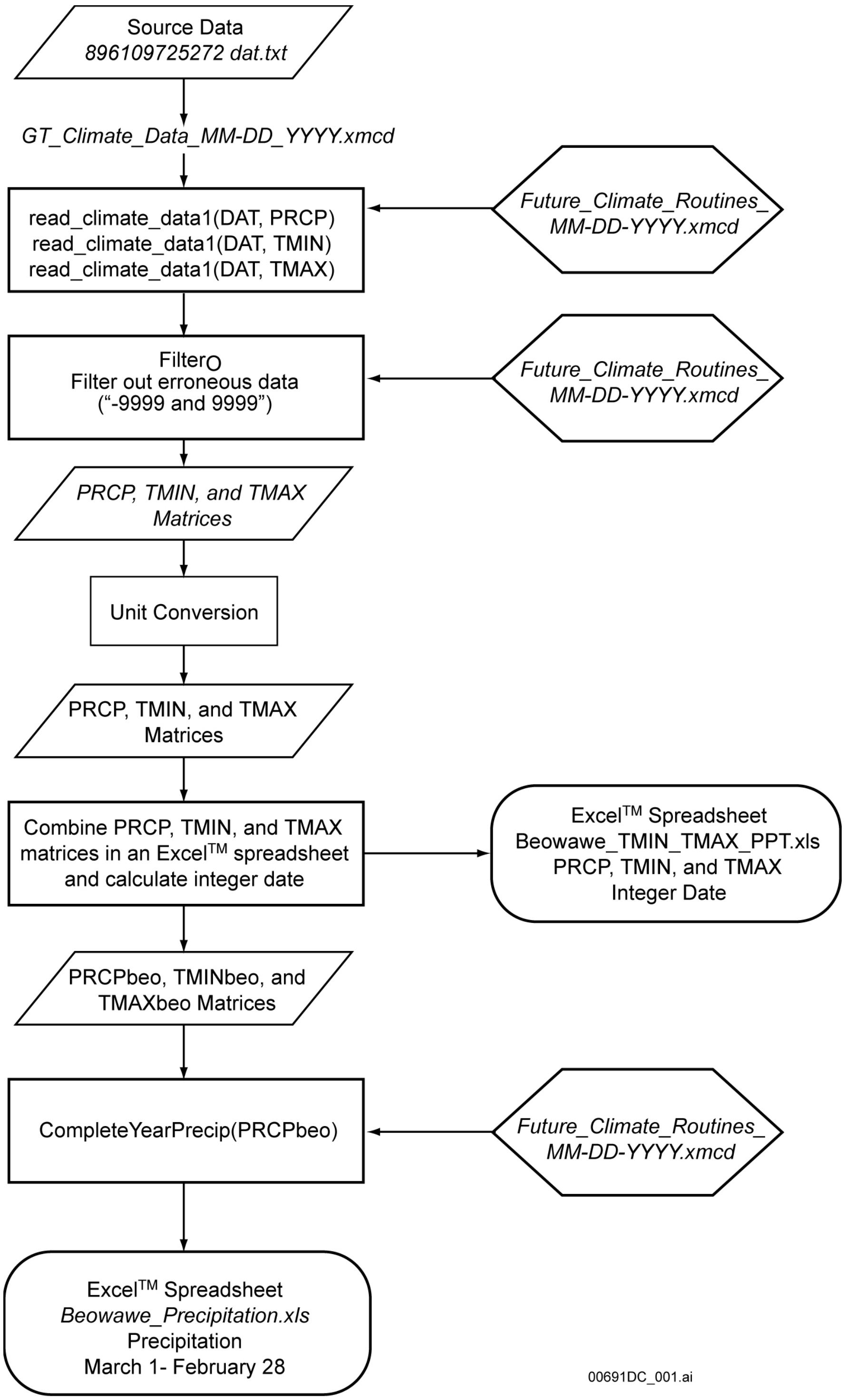
Using Mathcad®, the data from DTN: SN0512NOAADATA.003 [DIRS 176100] were input to two sets of Excel® files in output DTN: SN0603DWEATHER.002 (Sections 6.3.1 through 6.3.3). The first data set, listed in Table 6.3-3, provides "screened" precipitation data in millimeters, and minimum and maximum temperature data in degrees Celsius.

Table 6.3-3. Excel® Formatted Proxy Climate Meteorological Files

Excel® Files Containing Precipitation and Daily Minimum and Maximum Temperature (°C) Values	Site Location and NOAA Station ID Number	Source ("*.dat.txt*") File Name in DTN: SN0512NOAADATA.003 [DIRS 176100]
Beowawe_TMIN_TMAX_PPT.xls	Beowawe, Nevada COOP 260795	*896109725272dat.txt*
Delta _TMIN_TMAX_PPT.xls	Delta, Utah COOP 422090	*833900726569dat.txt*
Hobbs_TMIN_TMAX_PPT.xls	Hobbs, New Mexico COOP 294026	*64086727775dat.txt*
Nogales_TMIN_TMAX_PPT.xls	Nogales, Arizona COOP 025921	*721532727755dat.txt*
Rosalia_TMIN_TMAX_PPT.xls	Rosalia, Washington COOP 457180	*195364725137dat.txt*
Spokane_TMIN_TMAX_PPT.xls	Spokane, Washington COOP 457938 WBAN 24157	*906143725006dat.txt*
StJohn_TMIN_TMAX_PPT.xls	St. John, Washington COOP 457267	*978568725270dat.txt*

Source: Output DTN: SN0603DWEATHER.002.

ID = identification; NOAA = National Oceanic and Atmospheric Administration.



NOTE: Extraction is performed using Mathsoft® Mathcad® routines.

Figure 6.3-1. Example Climate Data Extraction Using Data from Beowawe, Nevada

The second set of Excel® files extracted with Mathcad® are a subset of the files listed in Table 6.3-4, belonging to output DTN: SN0603DWEATHER.002. This second set contains only precipitation data, and only includes years for which precipitation data exist for a consecutive 365- (or 366-) day period. In these files, the first day listed is the day before March 1 (either February 28 or February 29, depending on whether it is a leap year), although March 1 is the actual "start day" of the cycle, which ends February 28 (or February 29) of the following year.

This second set contains only precipitation data, and only includes years for which precipitation data exist for a consecutive 366-day period. In these files, the start of the cycle occurs on the day before March 1, and ends February 28 of the following year. March 1 is the start day of that cycle. Row 2 lists the year. Row 3 lists the precipitation on the day preceding March 1 (either February 28 or February 29, depending on whether it is a leap year). Rows 4 through 367 list the precipitation amounts in millimeters for each day from March 1 to February 28.

In output DTN: SN0603DWEATHER.002, the comment "day preceeding" [sic], located in row 3 of each worksheet, relates to either the precipitation record of February 28 or 29 for a leap year. As an example, in *Beowawe_Precipitation.xls* (Table 6-8), the first year listed starts on March 1, 1983, and ends February 28, 1984. The day preceding March 1, 1983, corresponds to February 28, 1983. In the source file for Beowawe, Nevada, March 1, 1983, through February 28, 1984, is the first complete 365-day cycle starting on the day before March 1. In the source file, the next year that includes a complete 366-day precipitation record is March 1, 1986, through February 28, 1987. Therefore, the next 366-day cycle in *Beowawe_Precipitation.xls* starts on the day before March 1, 1986.

The Excel® files generated by Mathcad®, and their associated years of precipitation data, are listed in Table 6.3-4.

Table 6.3-4. Precipitation File Names and Record Years

File Name	Data Years (extracted from Mathcad®)
Beowawe_Precipitation.xls	1983, 1986, 1987, 1988, 1989, 1993, 1994, 1995, 1999, 2001
Delta_Precipitation.xls	1972, 1973, 1975, 1976, 1978, 1979, 1980, 1981, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003
Hobbs_ Precipitation.xls	1952, 1954, 1955, 1957, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1982, 1983, 1985, 1986, 1987, 1988, 1990, 1992, 1993, 1994, 1996, 1998
Nogales_Precipitation.xls	1948, 1951, 1953, 1954, 1955, 1956, 1957, 1958, 1960, 1962, 1963, 1964, 1965, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982
Rosalia_Precipitation.xls	1953, 1956, 1958, 1959, 1960, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1973, 1975, 1976, 1977, 1978, 1980, 1981, 1982, 1983, 1985, 1986, 1987, 1988, 1993
Spokane_Precipitation.xls	1948, 1949, 1950, 1951, 1952, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1998, 1999, 2000, 2001, 2002, 2003

Table 6.3-4. Precipitation File Names and Record Years (Continued)

File Name	Data Years (extracted from Mathcad®)
StJohn_Precipitation.xls	1964, 1965, 1966, 1967, 1968, 1969, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1987, 1989, 1990, 1991, 1994, 2001

Source: Output DTN: SN0603DWEATHER.002.

6.3.5 Salient Points for Precipitation and Temperature

6.3.5.1 Precipitation

This section presents discussion and scatter and bar plots for precipitation at the seven locations (Beowawe, Delta, Hobbs, Nogales, Rosalia, Spokane, and St. John) that represent future climate conditions over the next 10,000 years at Yucca Mountain. Precipitation data (output DTN: SN0603DWEATHER.002) extend from March 1 to February 28 (or February 29, if a leap year) of the following year: Four plots are presented for each site, showing:

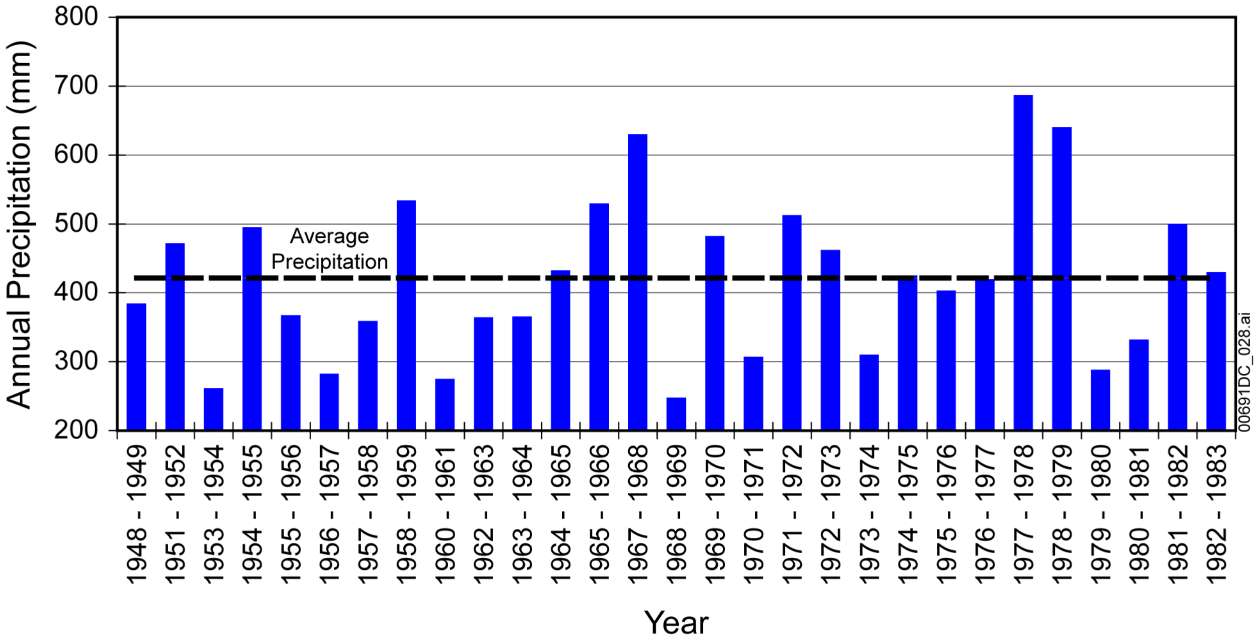
- The annual precipitation for each year, for which there are data, and the average annual precipitation (bar graph).
- The average daily precipitation, for each day of each applicable year (scatter plot). These scatter plots indicate the distribution of precipitation throughout the year.
- The distribution of average daily precipitation, which is also made clearer by averaging the precipitation for each Julian day (for example, the average of all daily precipitation data for January 1, including zero values is calculated, and likewise all other days of the year), and grouping these averages into 15-day intervals, then plotting the cumulative precipitation averages for the 15-day interval (bar graph). This interval size was selected as being small enough to show seasonal variability, yet large enough to minimize the influence of outlying data.
- The annual total precipitation values (histogram) with cumulative distribution.

Monsoon Climate

The upper-bound monsoon climate is represented by Nogales, Arizona, and by Hobbs, New Mexico (BSC 2004 [DIRS 170002]).

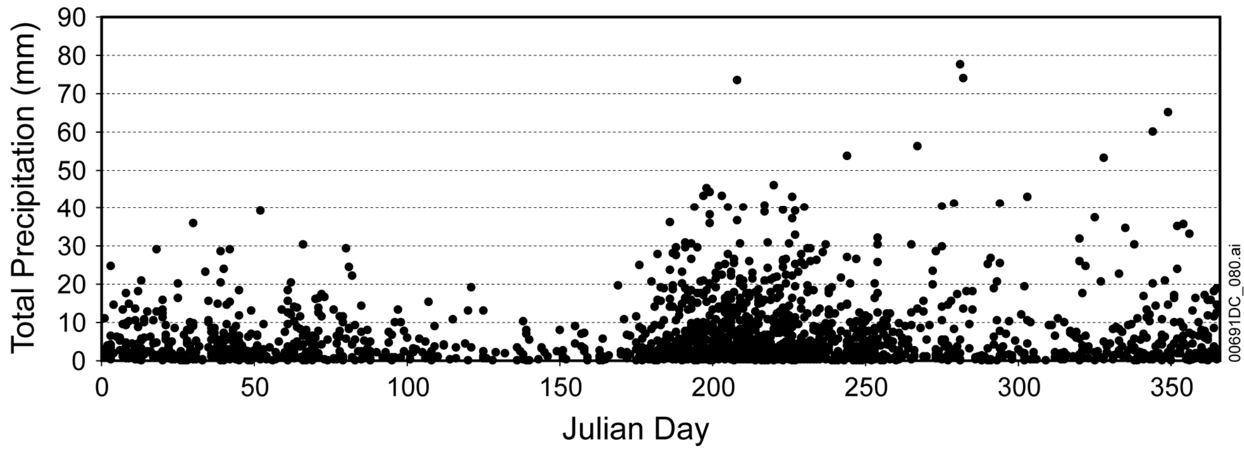
Based on 29 years of data, the highest annual precipitation for Nogales was 687 mm (occurring during the 1978-to-1979 cycle), and the lowest precipitation was 248 mm (occurring during the 1968-to-1969 cycle); average annual precipitation was 421 mm/yr (Figure 6.3-2). The wet season occurs from approximately Julian day 181 through Julian day 255, and is preceded by a dry spell that occurs from approximately Julian day 91 through Julian day 180, during which time precipitation tends to average less than 0.3 mm/day (Figures 6.3-3 and 6.3-4). Annual precipitation was between 350 and 450 mm/yr 34% of the time, and between 250 and 550 mm/yr 86% of the time. A histogram of annual precipitation for Nogales is provided as Figure 6.3-5.

Based on 37 years of data, the highest annual precipitation for Hobbs was 734 mm (occurring during the 1977-to-1978 cycle) and the lowest was 184 mm (occurring during the 1967-to-1968 cycle); average annual precipitation was 405 mm/yr (Figure 6.3-6). The wet season occurs between Julian day 136 and Julian day 270. The dry season extends from Julian day 316 through Julian day 90 of the following year (Figures 6.3-7 and 6.3-8); during this period precipitation tends to average less than 0.5 mm/day. Annual precipitation was between 200 and 300 mm/yr 32% of the time, and between 150 and 550 mm/yr 84% of the time. A histogram of annual precipitation for Hobbs is provided as Figures 6.3-9.



Source: See Appendix F.

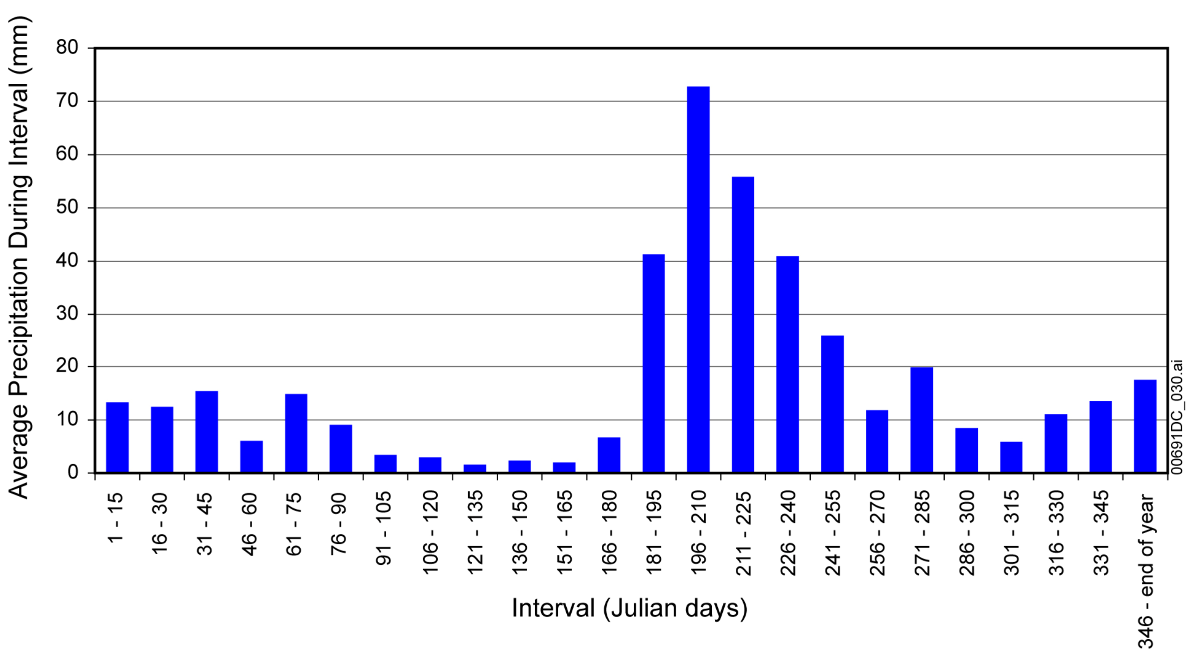
Figure 6.3-2. Annual and Average Precipitation at Nogales, Arizona (1948 through 1983)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

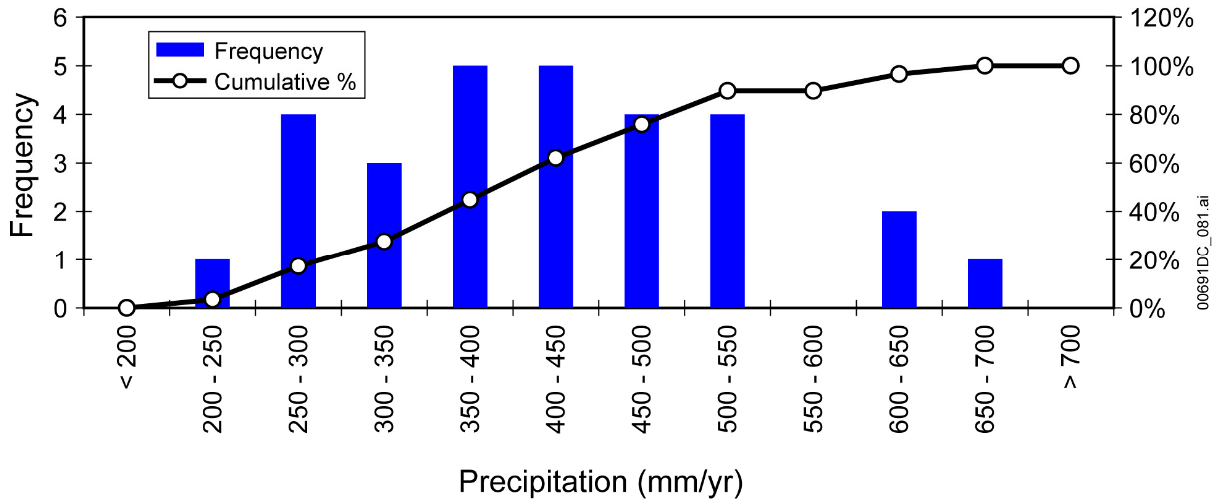
Figure 6.3-3. Daily Total Precipitation at Nogales, Arizona (1948 through 1983)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars. Data are average daily precipitation for years 1948 through to 1983, including years with incomplete data.

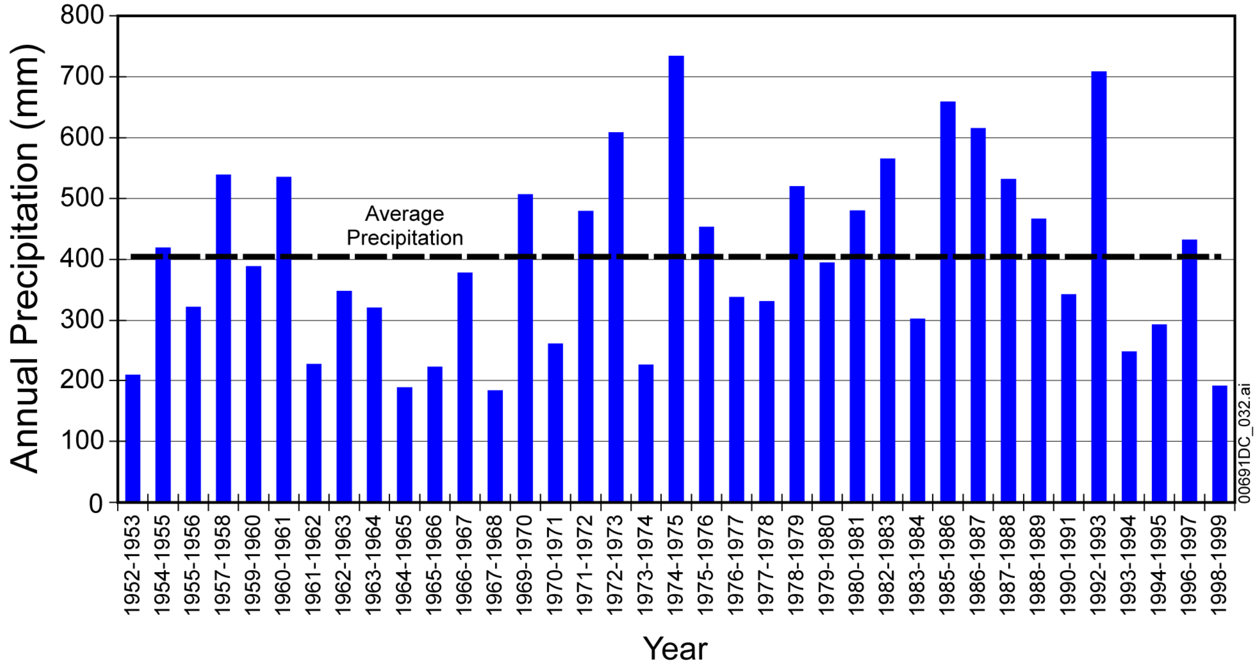
Figure 6.3-4. Average Precipitation for 15-Day Intervals at Nogales, Arizona (1948 through to 1983)



Source: See Appendix F.

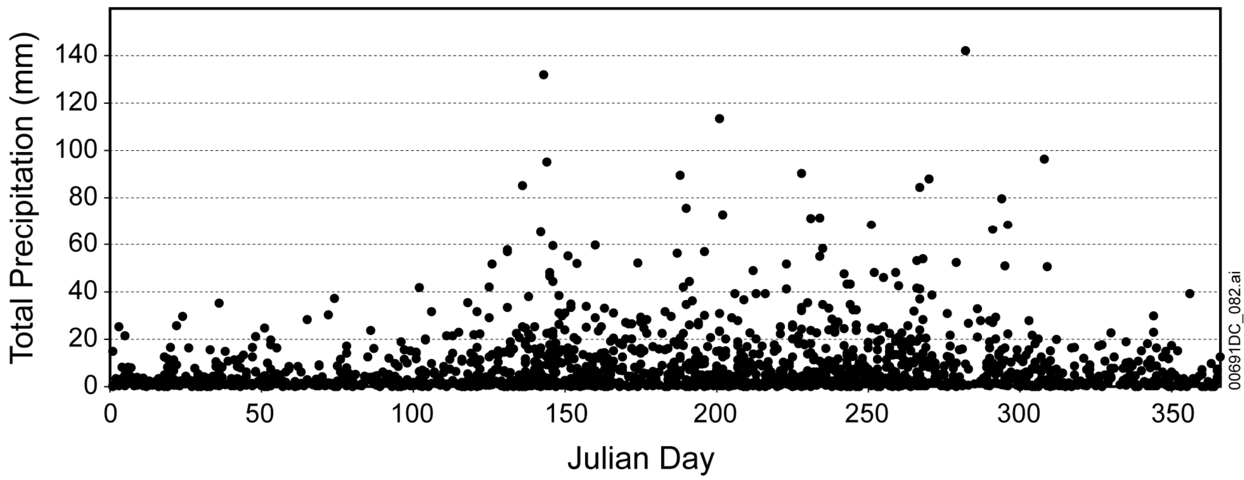
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-5. Histogram of Annual Precipitation at Nogales, Arizona (1948 through to 1983)



Source: See Appendix F.

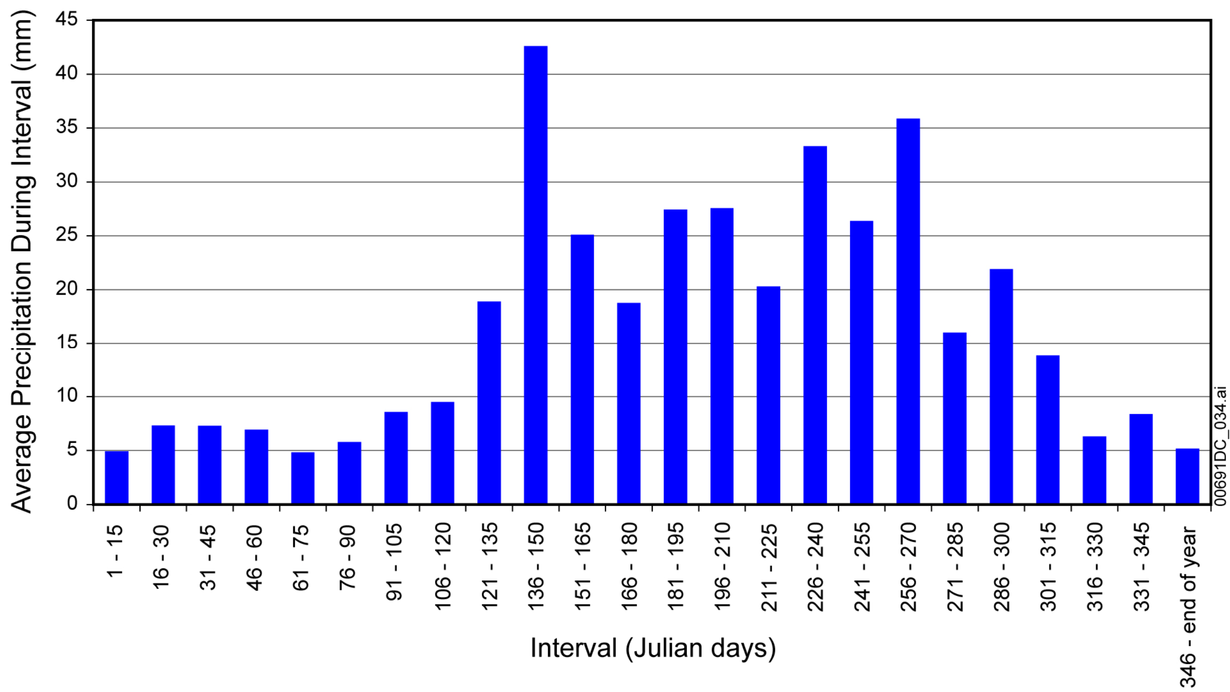
Figure 6.3-6. Annual and Average Precipitation at Hobbs, New Mexico (1952 through 1999)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

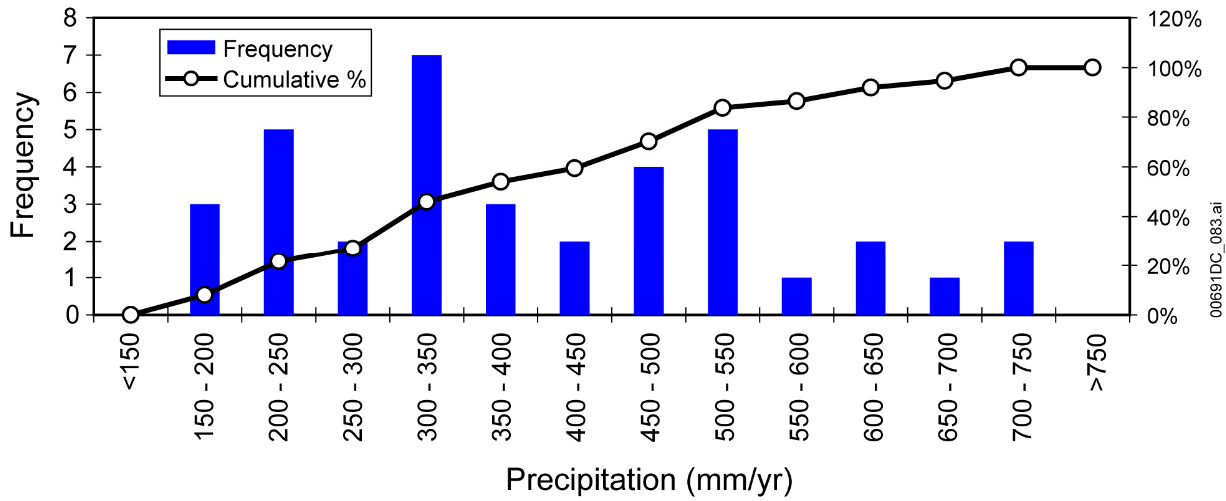
Figure 6.3-7. Daily Total Precipitation at Hobbs, New Mexico (1952 through 1999)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.3-8. Average Precipitation for 15-Day Intervals at Hobbs, New Mexico (1952 through 1999)



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-9. Histogram of Annual Precipitation at Hobbs, New Mexico (1952 through 1999)

Glacial Transition Climate

The upper-bound glacial transition climate is represented by Spokane, Washington; Rosalia, Washington; and St. John, Washington (BSC 2004 [DIRS 170002]). Spokane has the longest record of precipitation data.

Based on 52 years of data, the highest precipitation for Spokane was 614 mm (occurring during the 1948-to-1949 cycle) and the lowest was 233 mm (occurring during the 1976-to-1977 cycle) (Figure 6.3-10). The average annual precipitation for this location was 419 mm. Seasonally, precipitation is highest from Julian day 316 to Julian day 15 of the following year, and lowest between Julian day 181 and Julian day 255 (Figures 6.3-11 and 6.3-12). The highest daily precipitation events occurred on Julian days 144 and 160. Annual precipitation was between 350 and 450 mm 44% of the time, and between 300 and 500 mm 79% of the time. A histogram of annual precipitation for Spokane is provided as Figure 6.3-13.

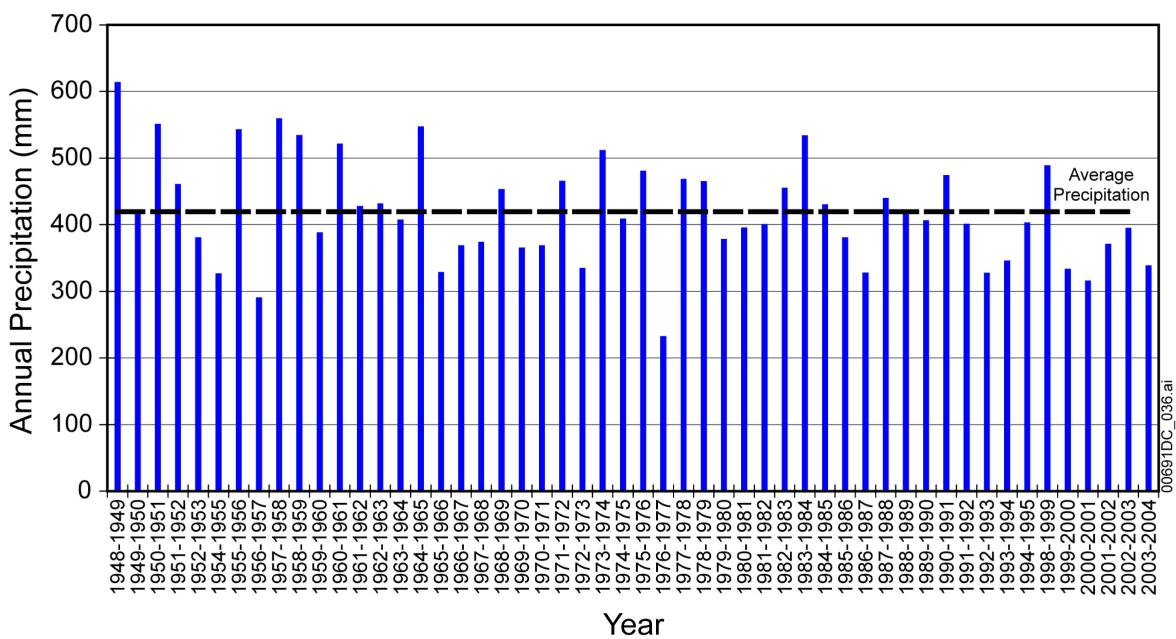
Based on 28 years of data, the highest annual precipitation for Rosalia was 581 mm (occurring during the 1980-to-1981 cycle) and the lowest was 249 mm (occurring during the 1976-to-1977 cycle). The average annual precipitation was 455 mm (Figure 6.3-14). Precipitation is highest from Julian day 316 to Julian day 30 of the following year, and lowest between Julian day 196 and Julian day 225 (Figures 6.3-14 and 6.3-16). During this period, precipitation tends to average less than 0.5 mm/day. Annual precipitation was between 350 and 500 mm 64% of the time, and between 350 and 600 mm 96% of the time. A histogram of annual precipitation for Rosalia is provided as Figure 6.3-17.

Based on 52 years of data, the highest annual precipitation for St. John was 558 mm (occurring during the 1973-to-1974 cycle) and the lowest was 302 mm (occurring during the 1976-to-1977 cycle). The average annual precipitation was 430 mm (Figure 6.3-18). Precipitation was highest from Julian day 316 to Julian day 15 of the following year, and lowest between Julian days 196 and 225 (Figures 6.3-19 and 6.3-20). During this period, precipitation tends to average less than 0.25 mm/day. Annual precipitation was between 350 and 450 mm 50% of the time, and between 300 and 550 mm 95% of the time. A histogram of annual precipitation for St. John is provided as Figure 6.3-21.

The lower bound of the glacial transition climate is represented by Beowawe, Nevada, and Delta, Utah (BSC 2004 [DIRS 170002).

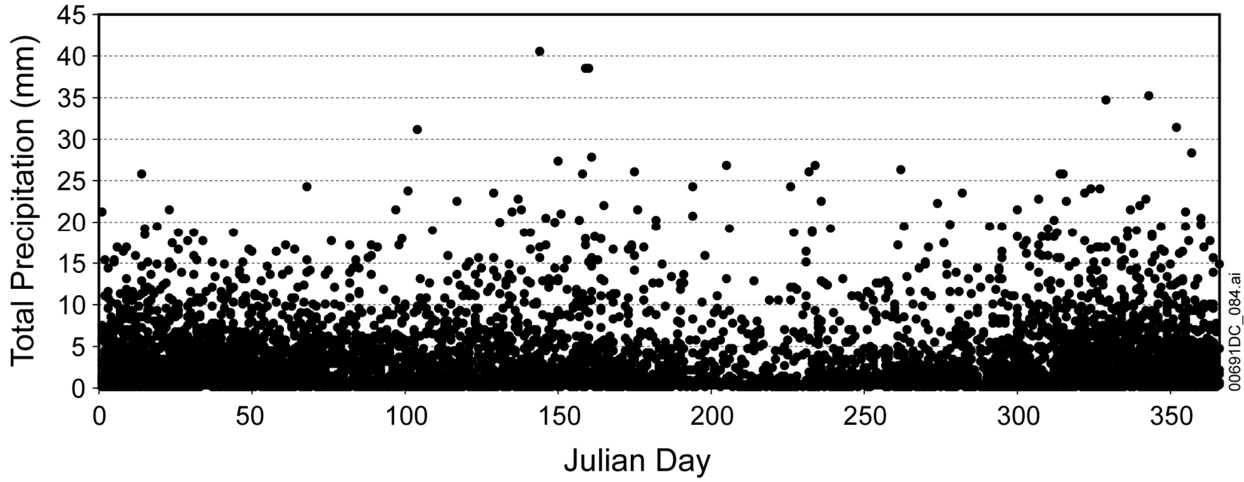
Based on 10 years of data, the highest annual precipitation at Beowawe was 390 mm (occurring during the 1983-to-1984 cycle) and the lowest was 144 mm (occurring during the 1986-to-1987 cycle). The average was 241 mm (Figure 6.3-22). Precipitation was highest between Julian day 106 and Julian day 165, and was immediately followed by a dry period from Julian day 166 through Julian day 270, during which precipitation tends to average less than 0.25 mm/day (Figures 6.3-23 and 6.3-24). Five of the 10 years had annual precipitation between 150 and 200 mm. A histogram of annual precipitation for Beowawe is provided as Figure 6.3-25.

Based on 29 calendar years of complete data, the highest annual precipitation at Delta was 304 mm (occurring during the 1981-to-1982 cycle) and the least was 97 mm (occurring during the 1976-to-1977 cycle), with an average annual precipitation of 207 mm (Figure 6.3-26). Precipitation at Delta is relatively evenly distributed throughout the year, except for three relatively short dry periods. Two occur during the winter months between Julian days 331 and 345, and Julian days 16 and 30. The third occurs during early summer between Julian days 166 and 195, when precipitation tends to average less than 0.25 mm/day (Figures 6.3-27 and 6.3-28). Annual precipitation was between 150 and 250 mm 72% of the time, and between 100 and 300 mm 93% of the time. A histogram of annual precipitation for Delta is provided as Figure 6.3-29.



Source: See Appendix F.

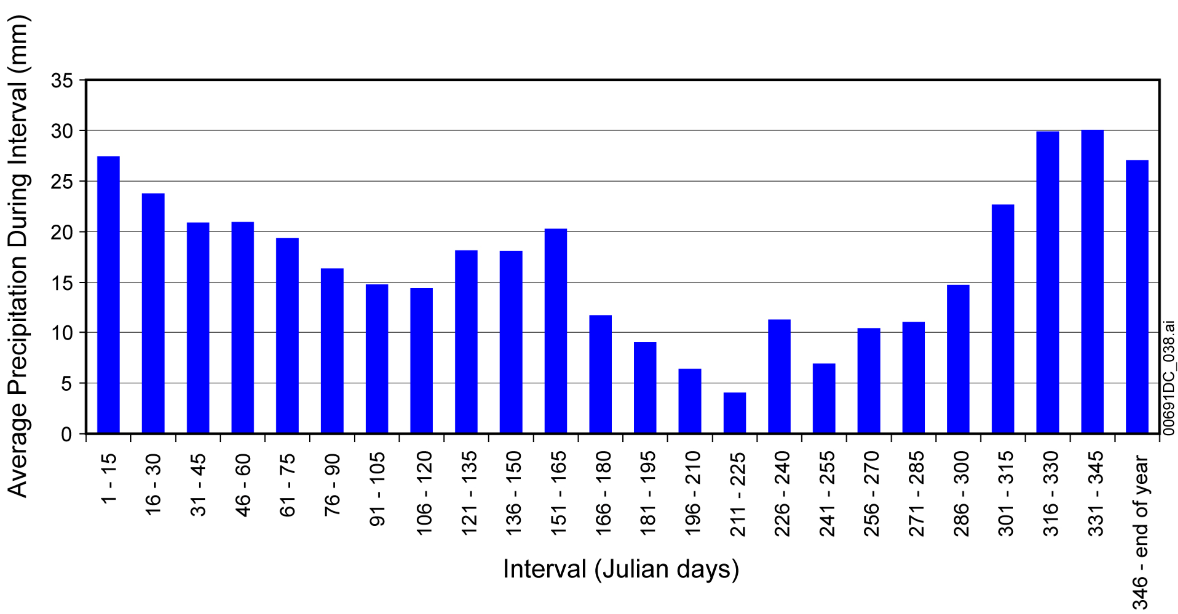
Figure 6.3-10. Annual and Average Precipitation at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

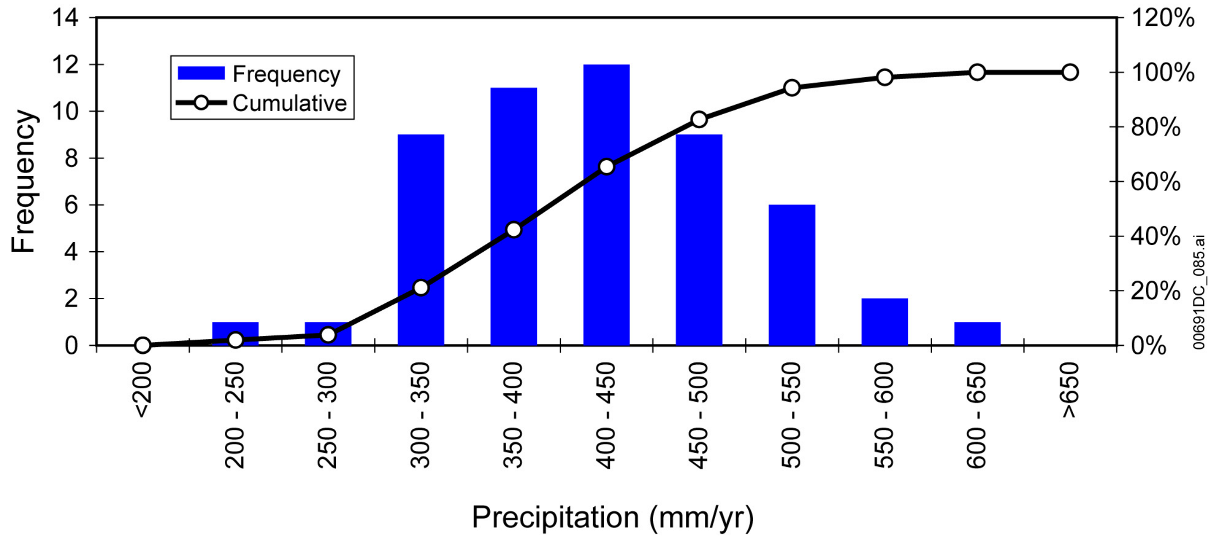
Figure 6.3-11. Daily Total Precipitation at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

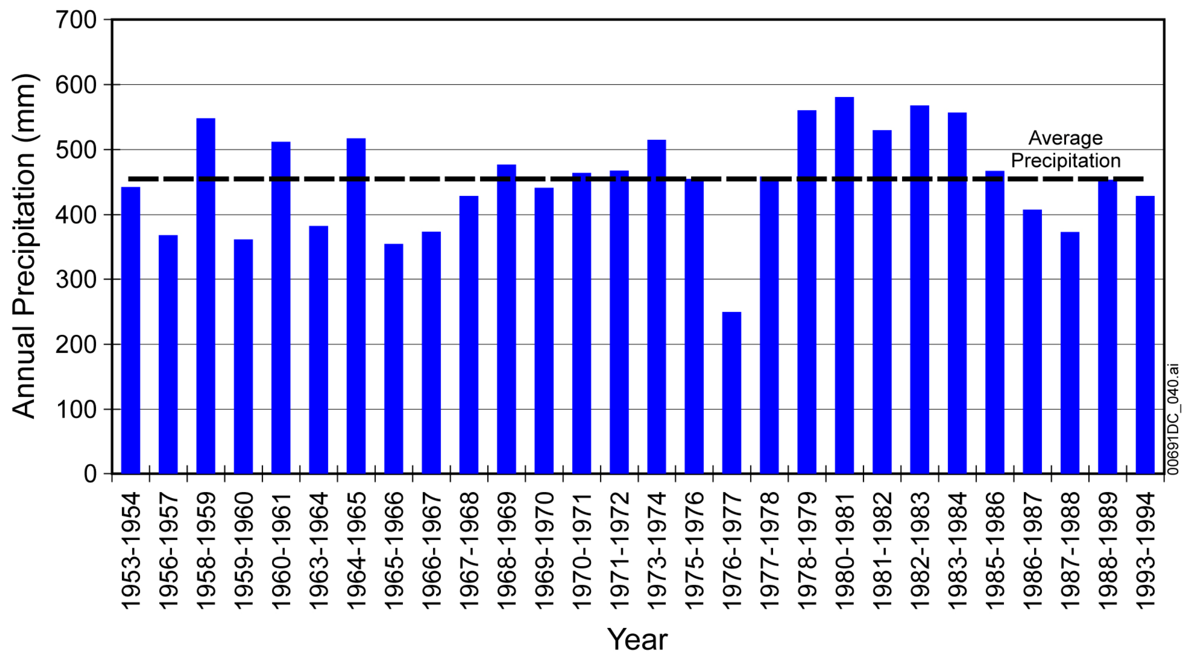
Figure 6.3-12. Average Precipitation for 15-Day Intervals at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

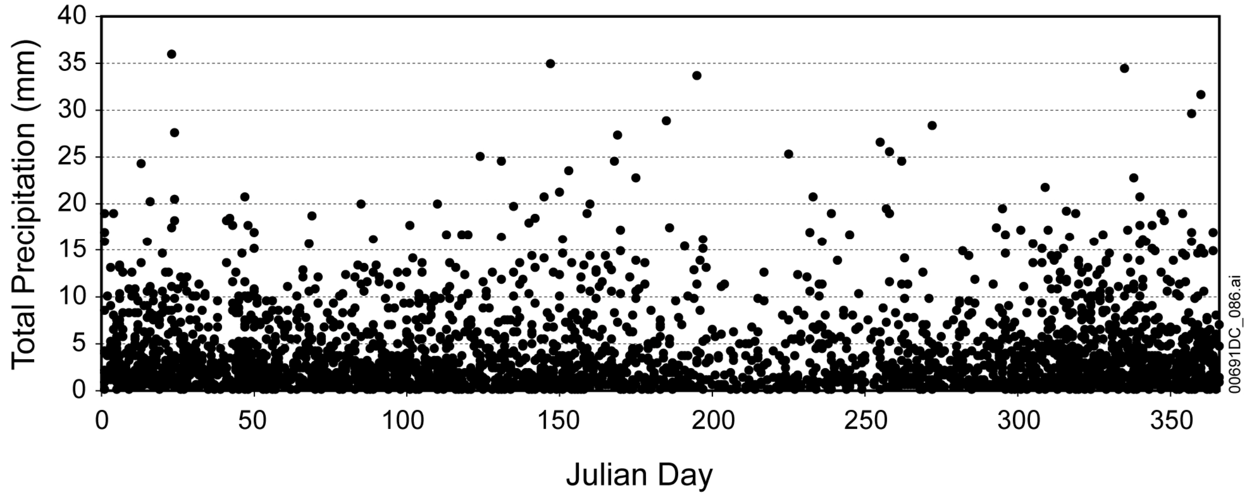
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-13. Histogram of Annual Precipitation at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

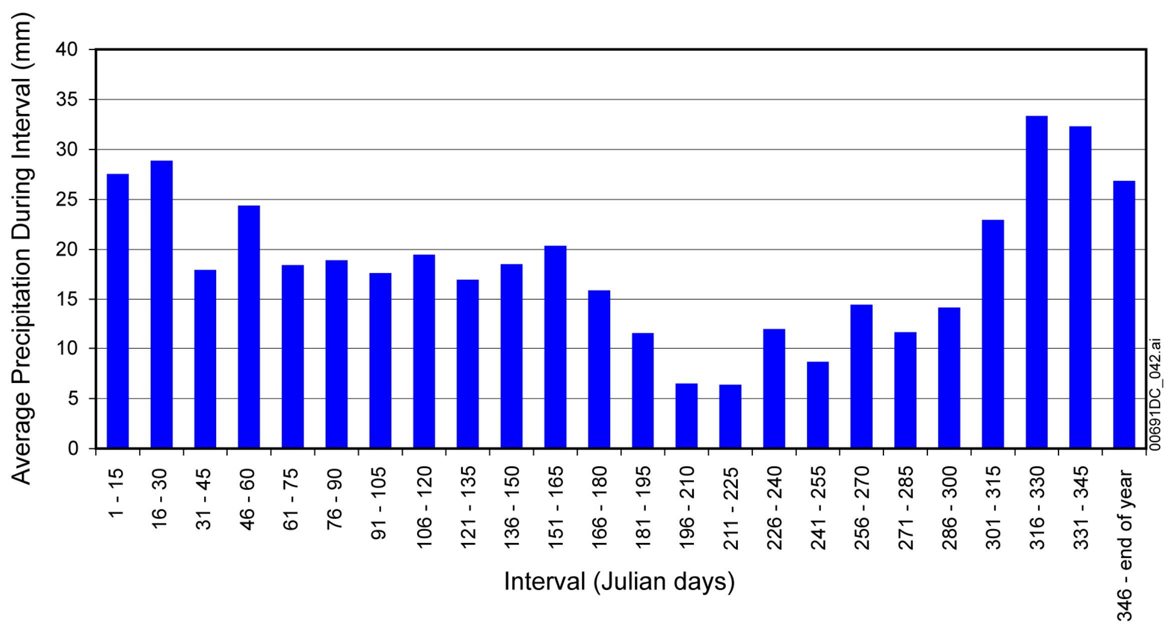
Figure 6.3-14. Annual and Average Precipitation at Rosalia, Washington (1953 through 1994)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

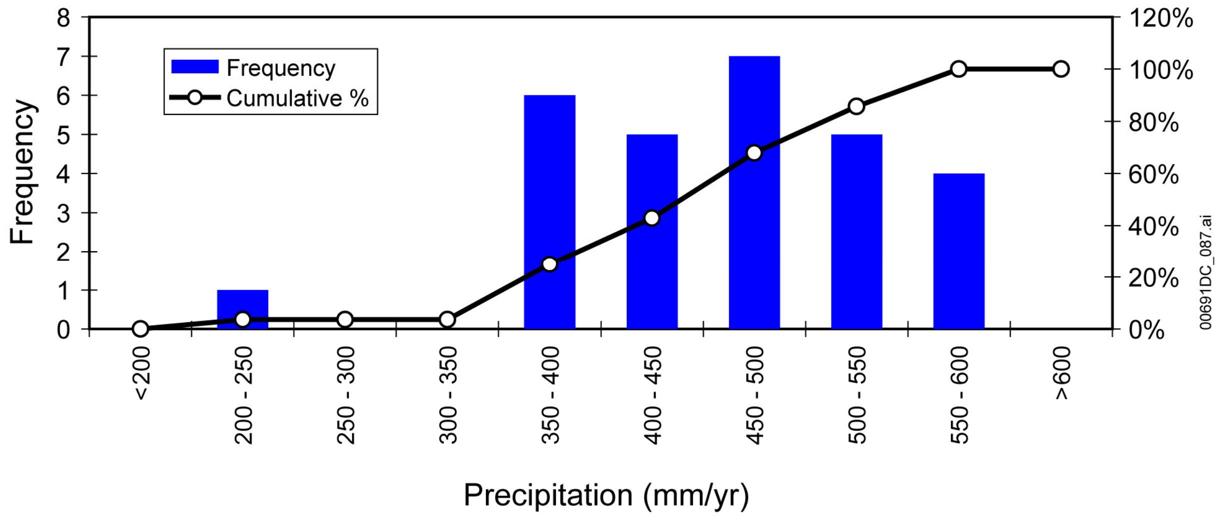
Figure 6.3-15. Daily Total Precipitation at Rosalia, Washington (1953 through 1994)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

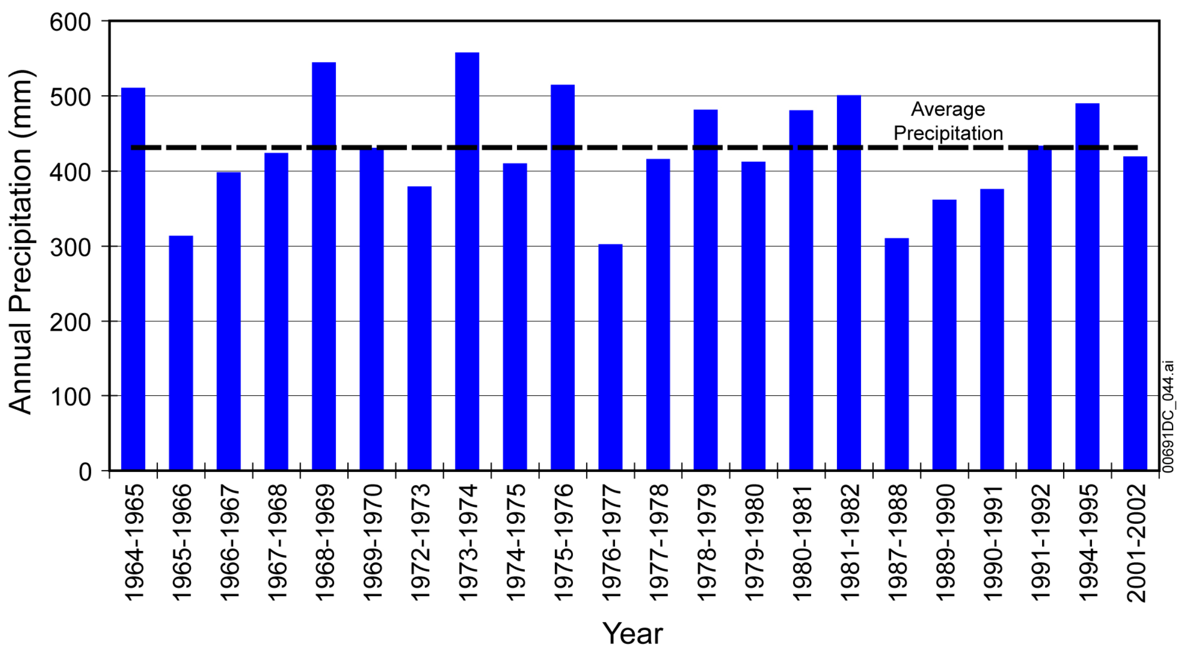
Figure 6.3-16. Average Precipitation for 15-Day Intervals at Rosalia, Washington (1953 through 1994)



Source: See Appendix F.

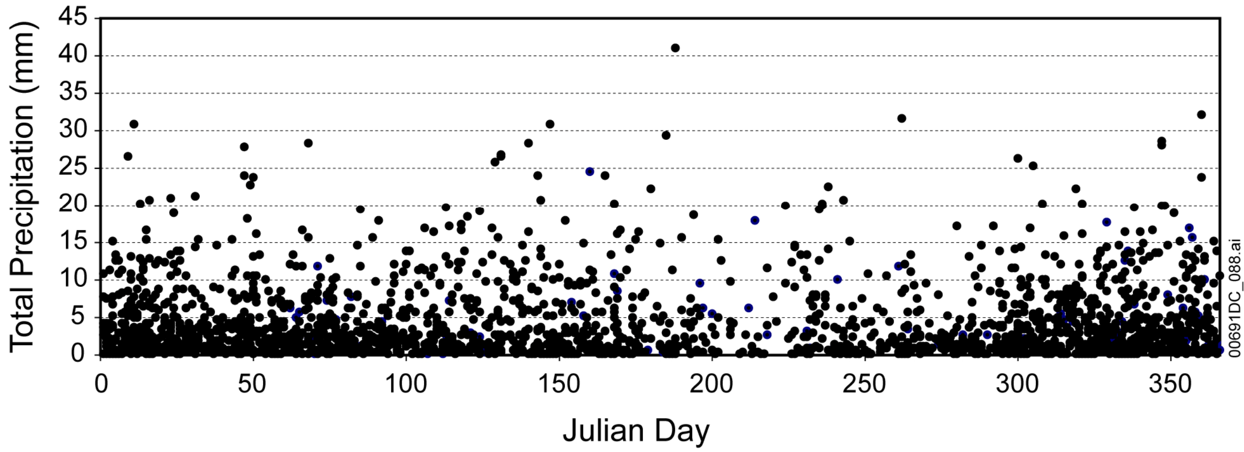
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-17. Histogram of Annual Precipitation at Rosalia, Washington (1953 through 1994)



Source: See Appendix F.

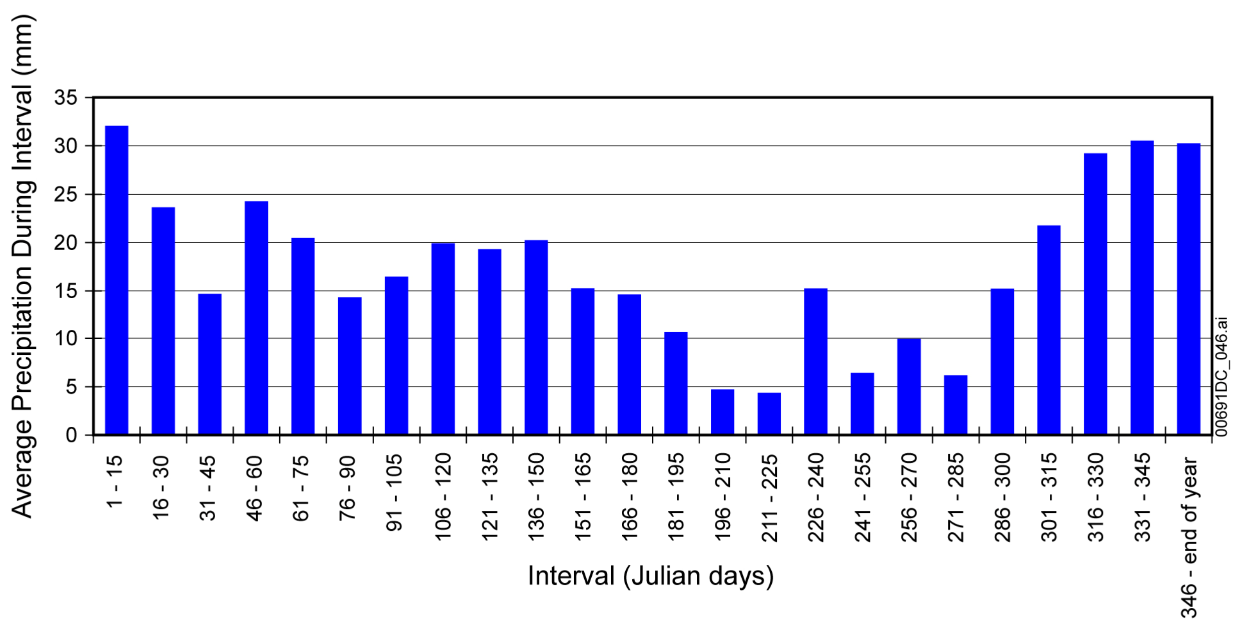
Figure 6.3-18. Annual and Average Precipitation at St. John, Washington (1964 through 2002)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

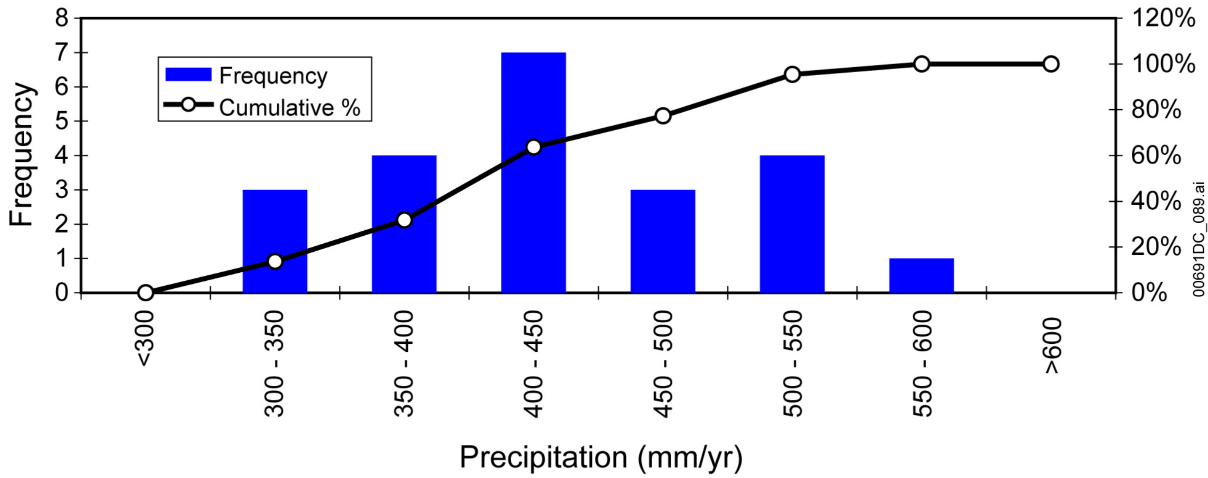
Figure 6.3-19. Daily Total Precipitation at St. John, Washington (1964 through 2002)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

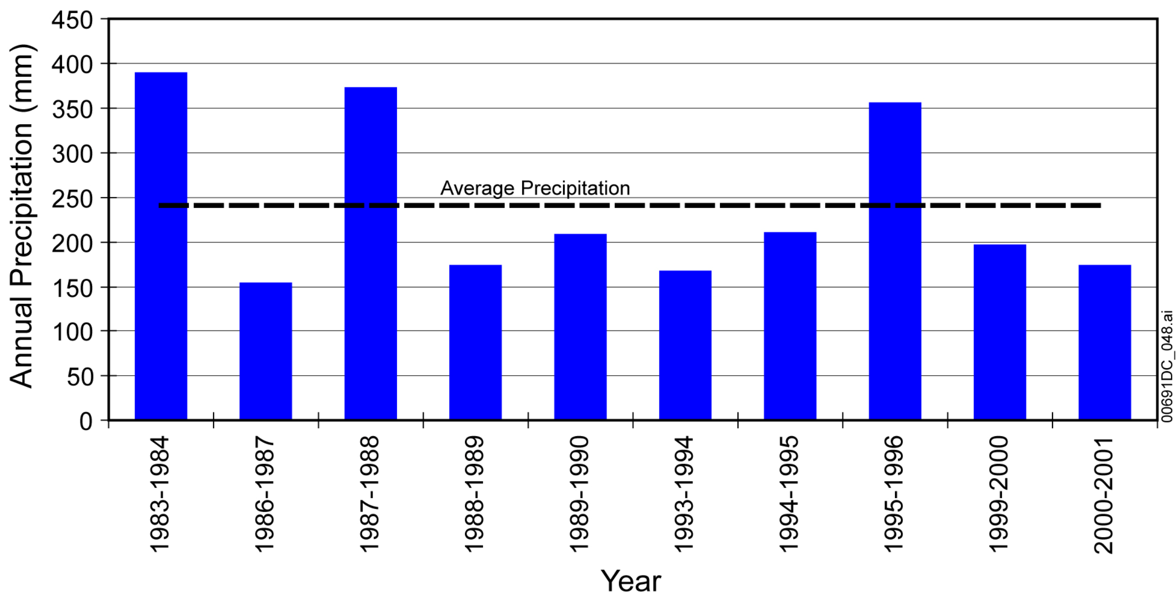
Figure 6.3-20. Average Precipitation for 15-Day Intervals at St. John, Washington (1964 through 2002)



Source: See Appendix F.

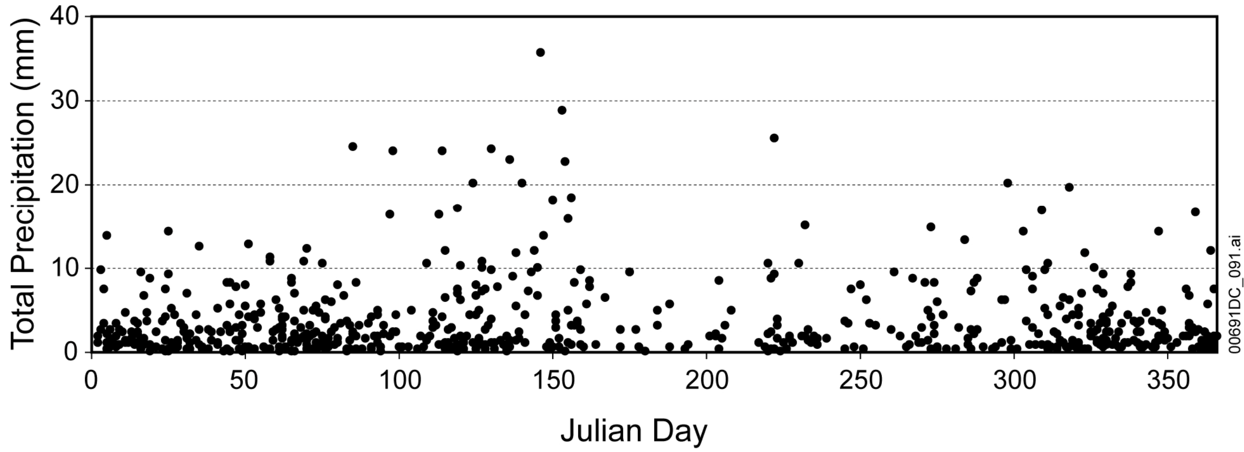
NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-21. Histogram of Annual Precipitation at St. John, Washington (1964 through 2002)



Source: See Appendix F.

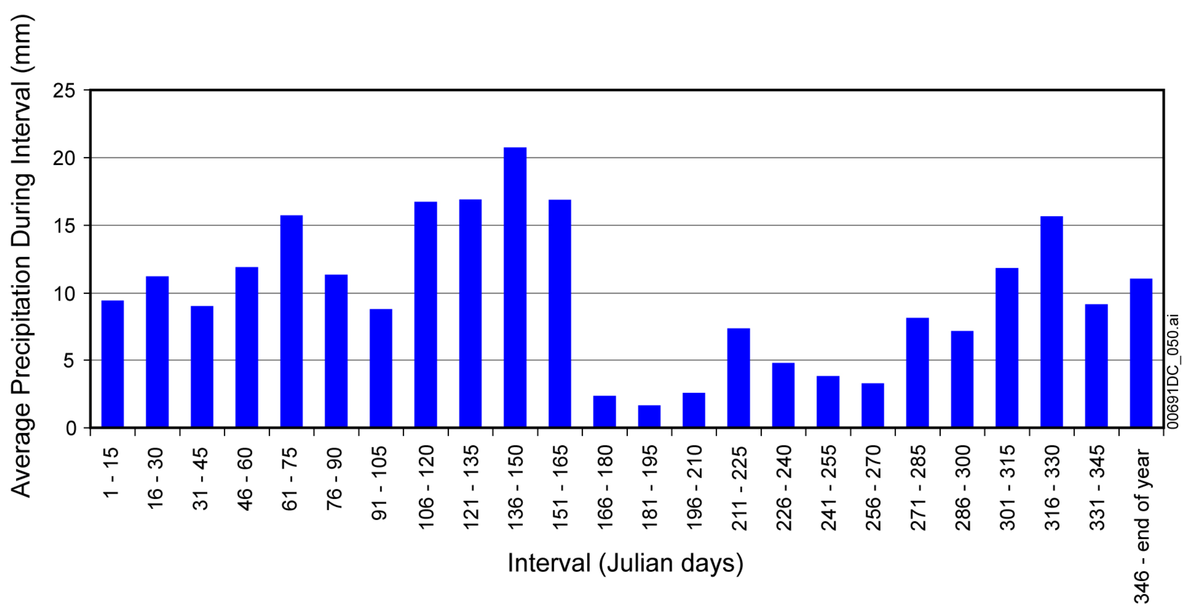
Figure 6.3-22. Annual and Average Precipitation at Beowawe, Nevada (1983 through 2002)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

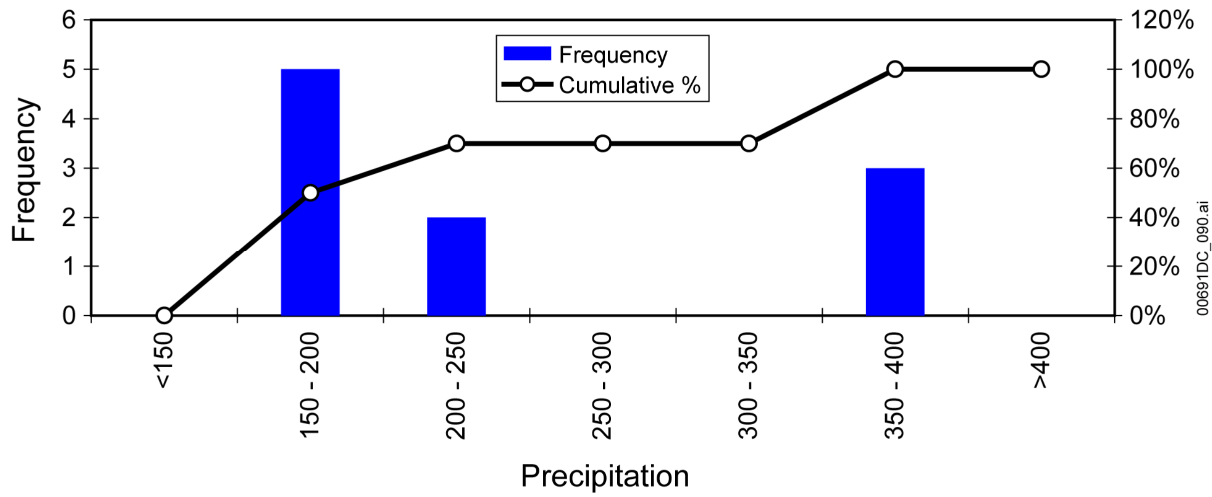
Figure 6.3-23. Daily Total Precipitation at Beowawe, Nevada (1983 through 2002)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

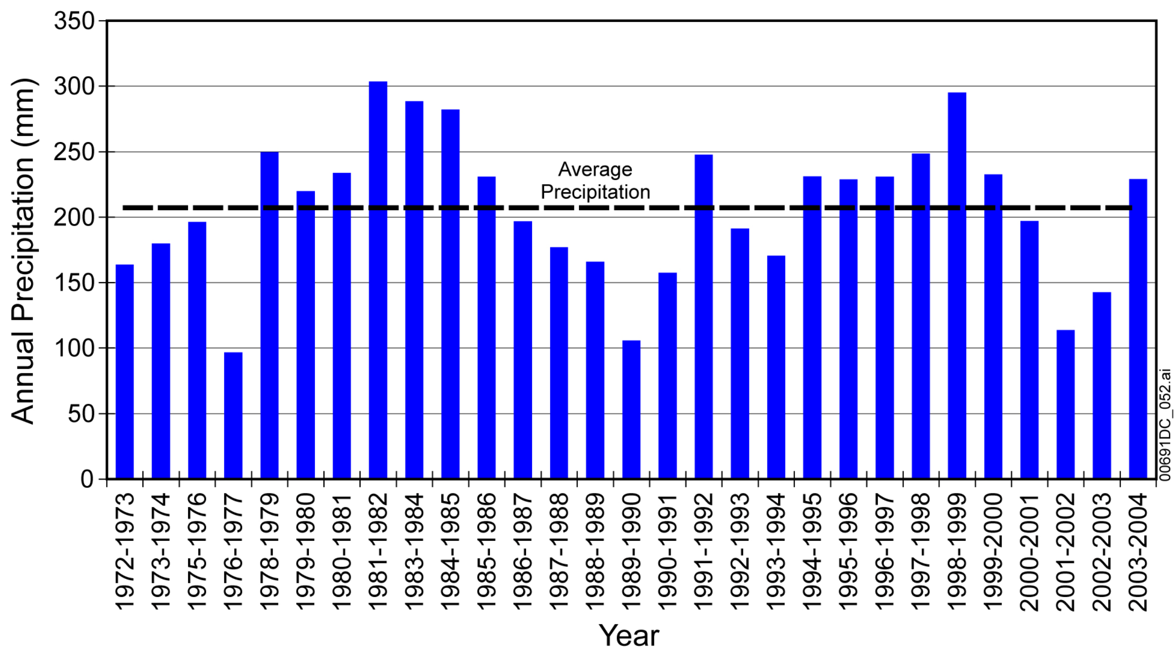
Figure 6.3-24. Average Precipitation for 15-Day Intervals at Beowawe, Nevada (1983 through 2002)



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

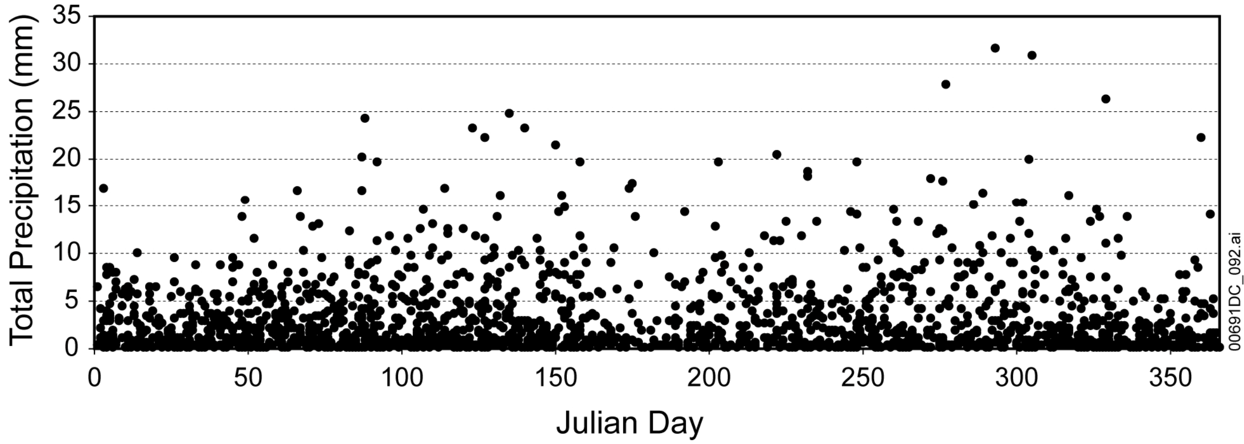
Figure 6.3-25. Histogram of Annual Precipitation at Beowawe, Nevada (1983 through 2002)



Source: See Appendix F.

NOTE: There are three gaps in the years shown on the graph.

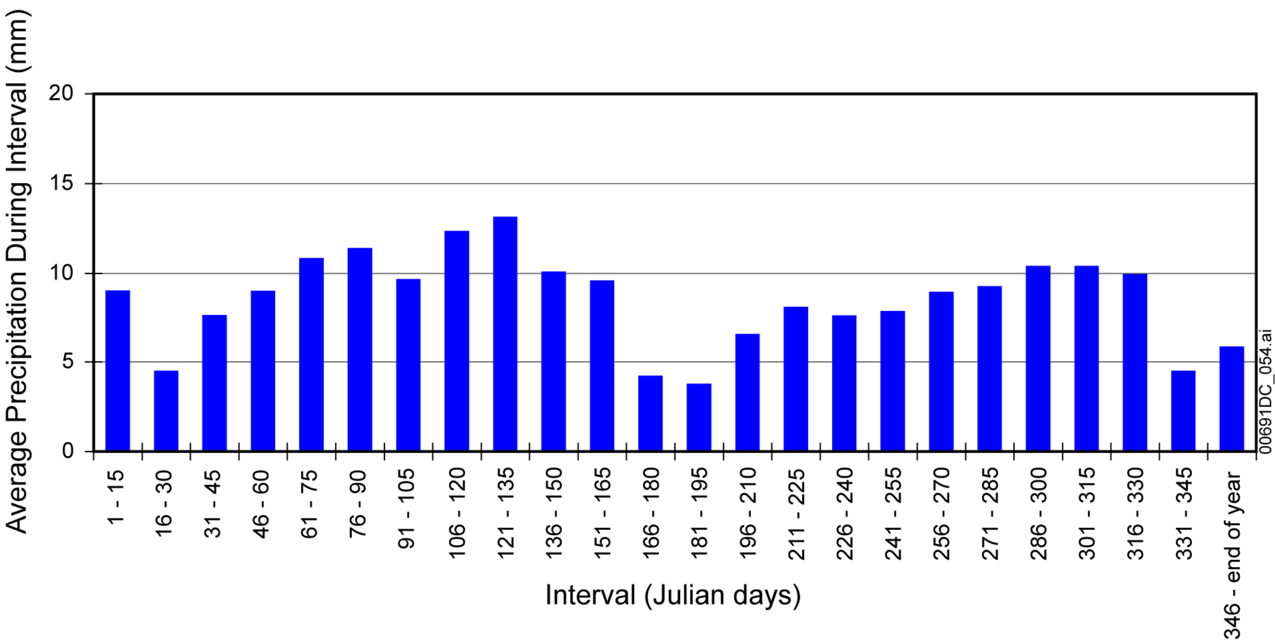
Figure 6.3-26. Annual and Average Precipitation at Delta, Utah (1972 through 2004)



Source: See Appendix F.

NOTE: For clarity purposes specific years are not given in the above plot.

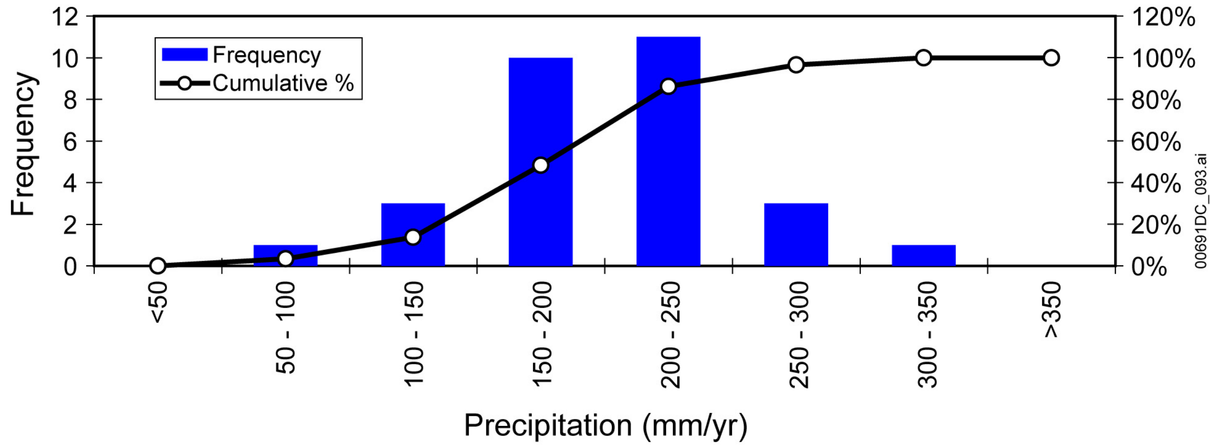
Figure 6.3-27. Daily Total Precipitation at Delta, Utah (1972 through 2004)



Source: See Appendix F.

NOTE: The last bar represents 20.25 days; the value was therefore reduced by factor of 0.74 (15/20.25) to normalize this value with other bars.

Figure 6.3-28. Average Precipitation for 15-Day Intervals at Delta, Utah (1972 through 2004)



Source: See Appendix F.

NOTE: Results are binned into groups arranged from lowest to highest annual precipitation. Frequency indicates the number of times in which annual precipitation falls within a specific bin size over the period of record.

Figure 6.3-29. Histogram of Annual Precipitation at Delta, Utah (1972 through 2004)

6.3.5.2 Temperature – Future Climate Proxy Stations

This section presents daily minimum and maximum temperatures recorded at the seven locations that represent future climate conditions over the next 10,000 years at Yucca Mountain. The temperature data for these locations are taken from output DTN: SN0603DWEATHER.002. The data in output DTN: SN0603DWEATHER.002 are formatted such that the temperature cycle starts on March 1 (or February 29, in the case of a leap year) and ends on February 28 of the following year.

The temperature plots presented in this section start at the beginning of the calendar year, the first day being Julian day 1. For each of the seven locations, there are four plots of temperature data, as follows:

- Two scatter plots: The first scatter plot illustrates the daily maximum temperature values recorded at each site for every year of record. The second scatter plot illustrates the daily minimum temperature. The average daily minimum and maximum temperatures calculated over the timeframes of record are also plotted in each figure, to show how the recorded daily maximum and minimum temperatures fluctuate around the mean value for the period of record. Daily minimum and maximum calculated average temperatures are indicated in each scatter plot with black symbols.

- Two line plots: The first line plot illustrates the average maximum daily temperature calculated for the period of record, and includes one standard deviation above and below the average for maximum temperature. The second line plot illustrates the average minimum daily temperature at each location. These two lines plots show where the majority of the maximum and minimum temperature values recorded at each site fall for the period of record.

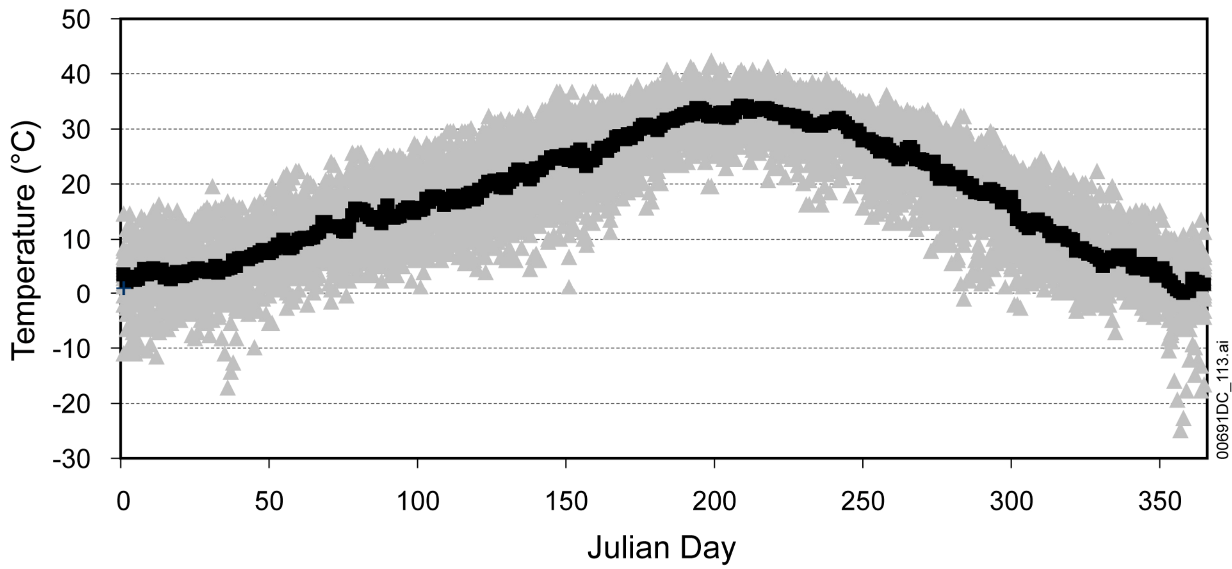
6.3.5.2.1 Beowawe, Nevada

Daily maximum and minimum temperatures at Beowawe, Nevada, for the period 1982 through 2004, are illustrated in Figures 6.3-30 and 6.3-31. To identify general temperature patterns and trends, the average minimum and maximum temperatures, plus and minus one standard deviation, were plotted in Figures 6.3-32 and 6.3-33. The overall trend reflects the standard seasonal temperature profile.

The average annual maximum temperature, approximately 34°C, occurs on or about Julian day 209 after a gradual upward trend that starts near the beginning of the year (Figure 6.3-32). After Julian Day 209, maximum daily temperature decreases at a slightly steeper rate than that seen when temperature maximums were increasing. Temperatures reach their lowest average minimum value around Julian day 358, and this lowest value is followed by a sudden increase of 2°C to 3°C. The same overall annual trend, seen in the average maximum temperature, is reflected in the average minimum temperature data in Figure 6.3-33. The marked dip occurs near Julian day 359, to an average minimum of −13.7°C, and is followed by a sudden increase that averages 3°C to 4°C over the next four days.

The highest minimum temperature occurs in summer (Julian days 180 through 220), with a range varying between plus or minus 3°C to 4°C. Another minimum appears in the late fall (Julian days 330 through 350) in a slightly wider range (of approximately plus or minus 3°C to 5°C).

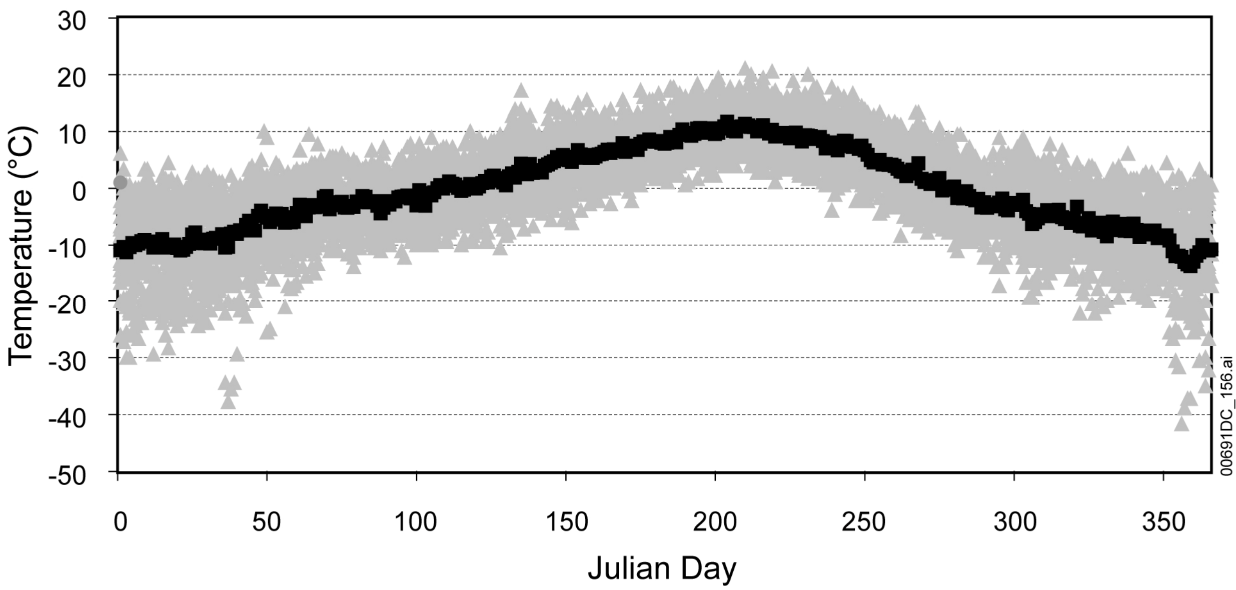
Temperature fluctuation is reduced in the summer period. The average minimum daily temperature, and the plus-and-minus one standard deviation of the average, indicate that the average minimum temperature (Figure 6.3-33) is least stable in the winter months (Julian days 1 through 80, and Julian days 280 through 365), in the range of approximately plus or minus 6°C to 9°C. The average minimum temperature exhibits the greatest stability during the spring and summer (Julian days 165 through 210), in the range of approximately plus or minus 2°C to 4°C.



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

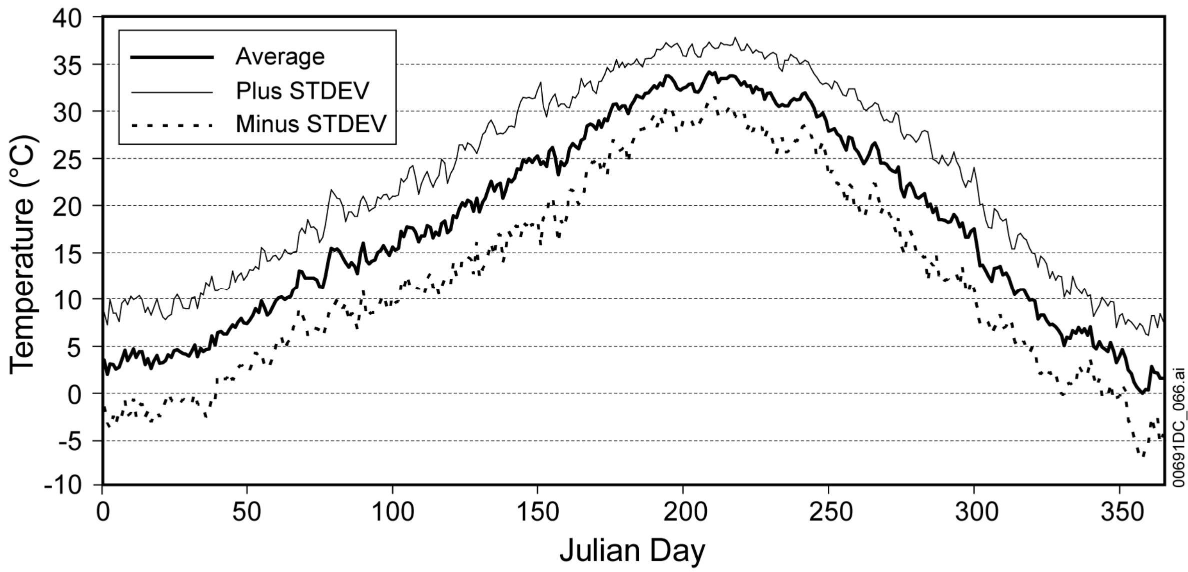
Figure 6.3-30. Daily Maximum Temperatures Recorded at Beowawe, Nevada (1982 through 2004)



Source: See Appendix F.

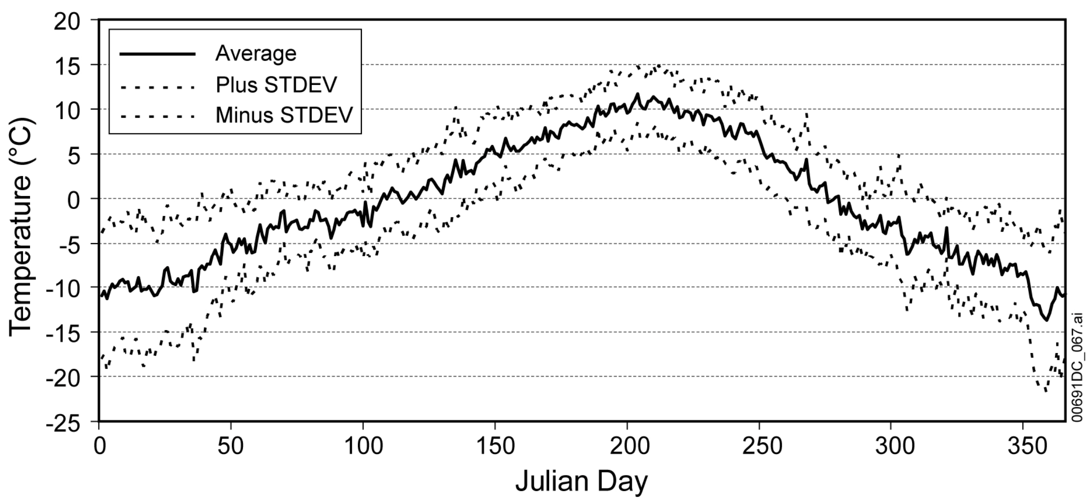
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-31. Daily Minimum Temperatures Recorded at Beowawe, Nevada (1982 through 2004)



Source: See Appendix F.

Figure 6.3-32. Average Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Beowawe, Nevada (1982 through 2004)



Source: See Appendix F.

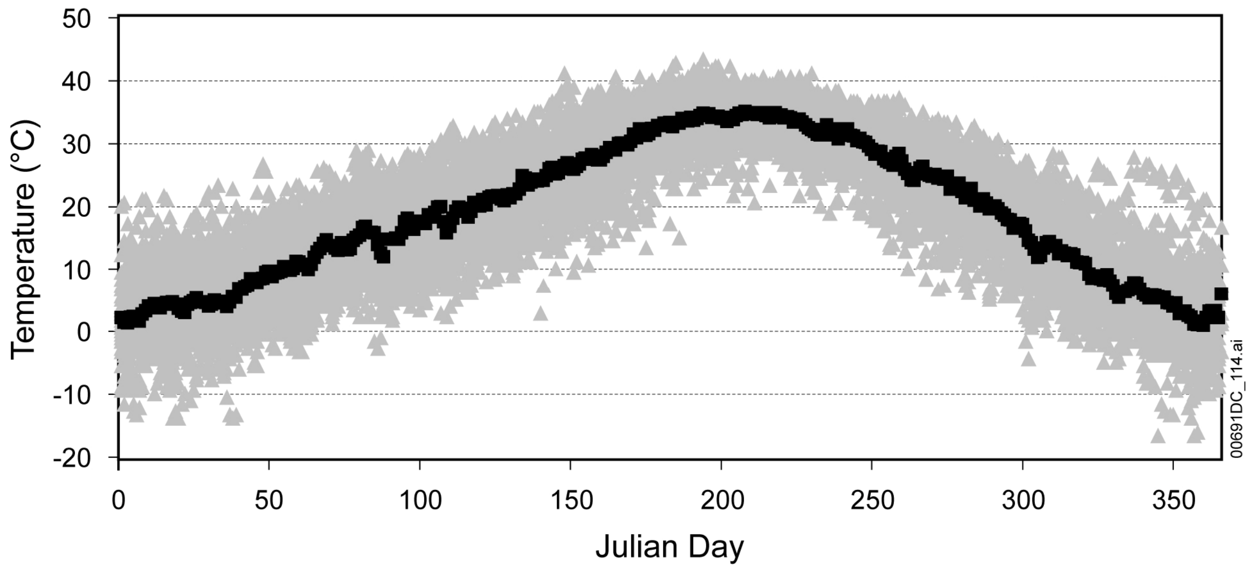
Figure 6.3-33. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Beowawe, Nevada (1982 through 2004)

6.3.5.2.2 Delta, Utah

Daily maximum and minimum temperatures recorded at Delta, Utah, between 1968 through 2004, are plotted in Figures 6.3-34 and 6.3-35. Average maximum and minimum temperatures, plus and minus one standard deviation for the same period, are plotted in Figures 6.3-36 and 6.3-37. The overall trend is average temperatures that follow a standard seasonal temperature profile.

The average annual maximum temperature of 35°C occurs on or about Julian day 208, after a gradual upward trend starting near the beginning of the year (Figure 6.3-36). After this date, a downward trend in temperature begins, but at a slightly steeper rate, reaching an average minimum temperature of −12.9°C on Julian day 360.

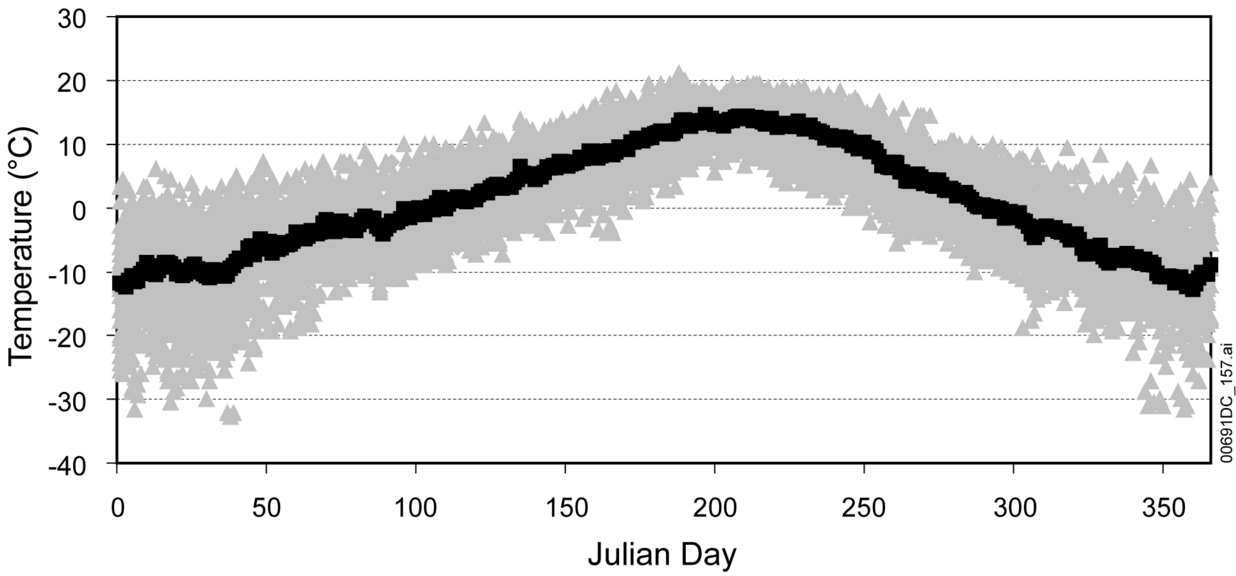
There is a relatively smooth seasonal variation in the standard deviation for average minimum temperature (Figure 6.3-37). The average daily minimum temperature appears to be the least stable in late December through the end of March (Julian day 355 through day 70), in the range of approximately plus or minus 6°C to 8°C. The standard deviation appears to become more stable after Julian day 100, where it begins the transition to a more stable summer season. The average daily minimum temperature exhibits the greatest stability during the summer (Julian days 190 through 220), in the range of plus or minus 2°C to 3°C.



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

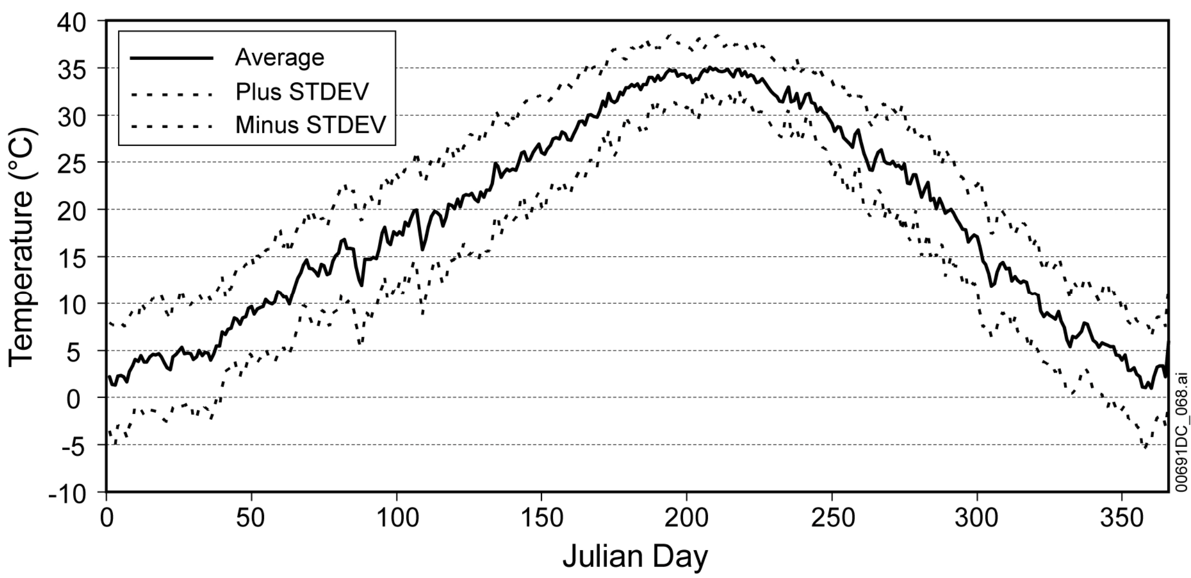
Figure 6.3-34. Daily Maximum Temperatures Recorded at Delta, Utah (1971 through 2004)



Source: See Appendix F.

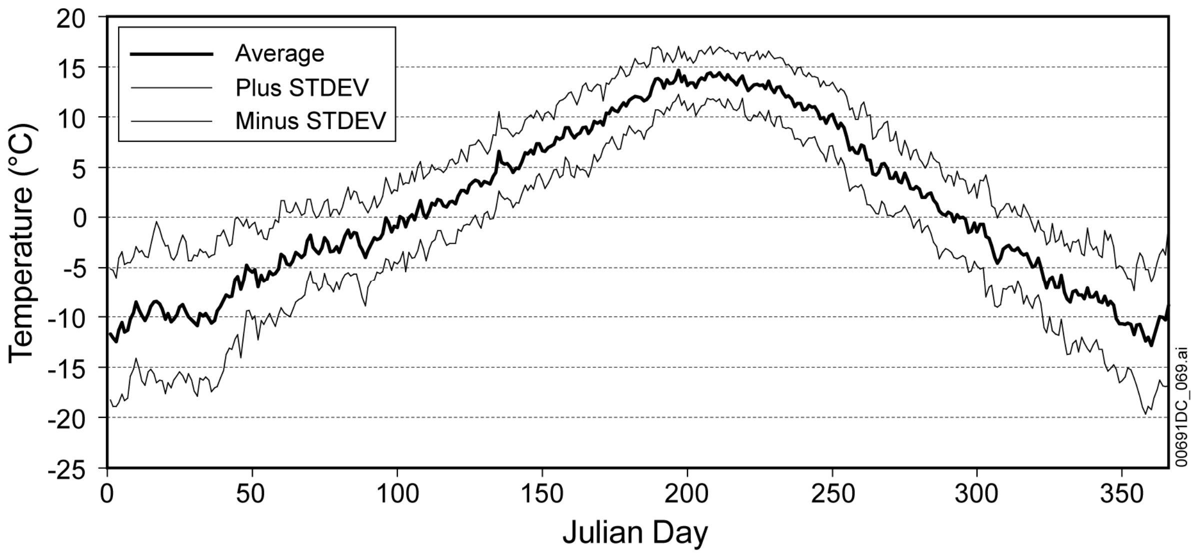
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-35. Daily Minimum Temperatures Recorded at Delta, Utah (1968 through 2004)



Source: See Appendix F.

Figure 6.3-36. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Delta, Utah (1968 through 2004)



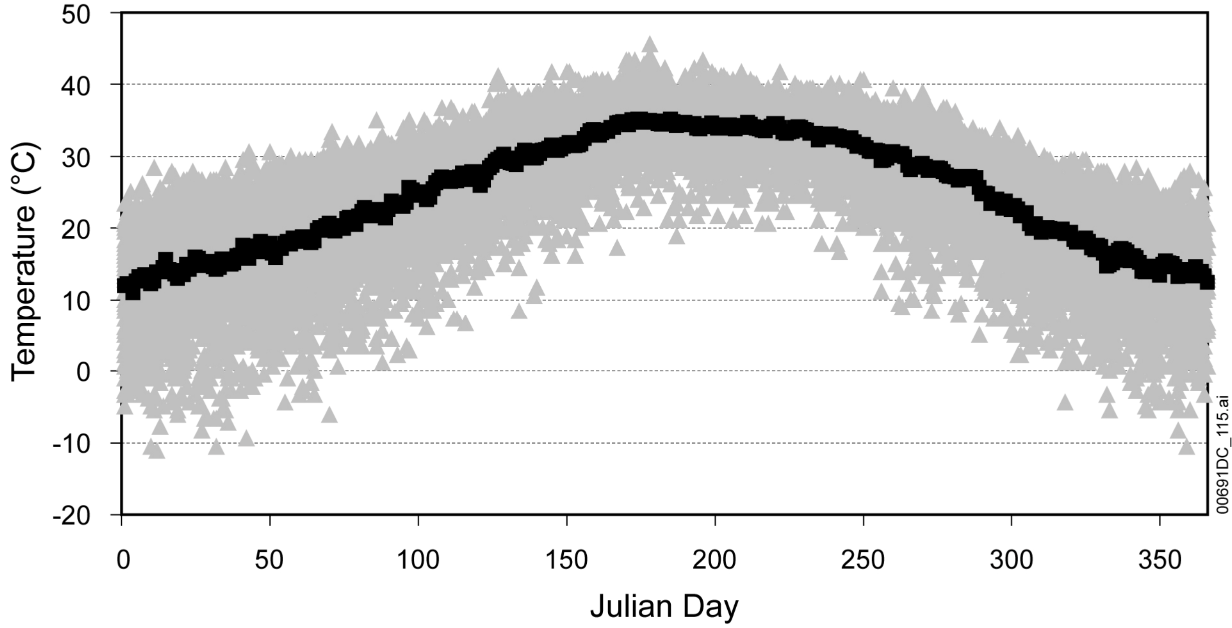
Source: See Appendix F.

Figure 6.3-37. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Delta, Utah (1968 through 2004)

6.3.5.2.3 Hobbs, New Mexico

Daily maximum and minimum temperatures recorded at Hobbs, New Mexico, for the period 1947 through 2004, are plotted in Figures 6.3-38 and 6.3-39. Average minimum and maximum daily temperatures plus or minus one standard deviation are plotted in Figures 6.3-40 and 6.3-41. The overall trend reflects the standard seasonal temperature profile.

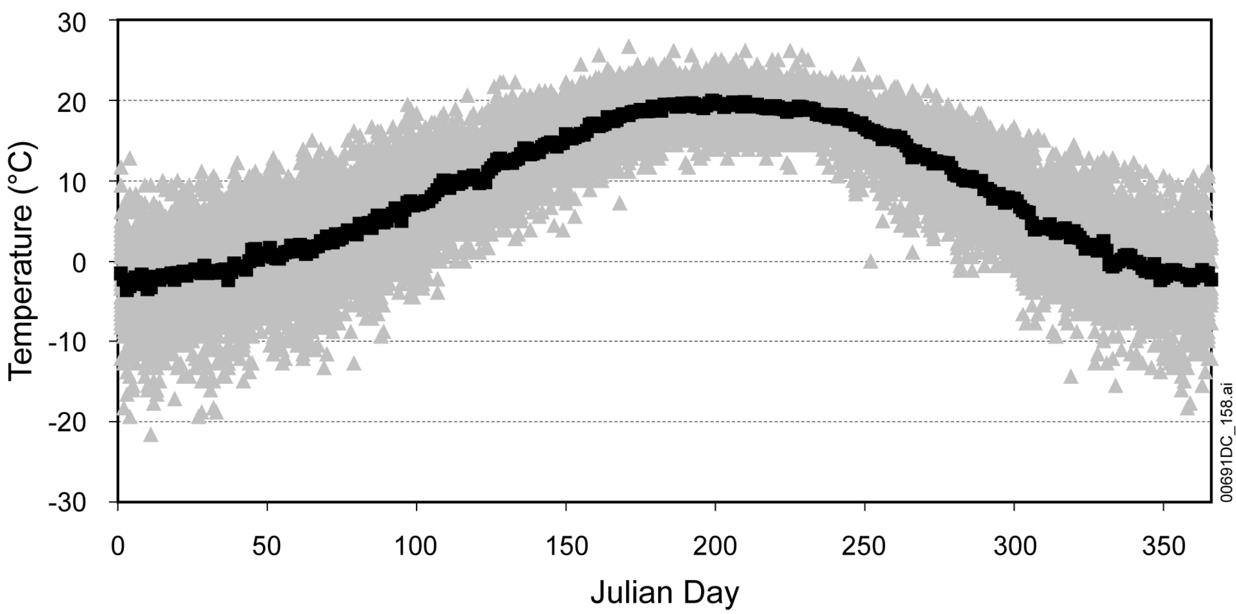
The average annual maximum temperature varies between 11°C and 35.2°C. The average maximum peaks on or about Julian day 174, after a gradual upward trend that starts near the beginning of the year (Figure 6.3-40). After the early summer peak, a downward trend begins, but at a more gradual rate. This trend is nearly flat until Julian days 230 through 240, when the downward trend increases, dropping to an average minimum of −3.6°C on or about Julian day 3. The average maximum temperature, and its respective standard deviation above and below the average, depicts a relatively gradual decrease from winter to summer and back to winter in the standard deviation (Figure 6.3-40). A maximum standard deviation of plus or minus 5°C to 8°C (relatively unstable) occurs in the early winter (Julian days 350 through 25). The standard deviation tends to decrease (become more stable) to a minimum range of approximately plus or minus 2.5°C to 4°C in midsummer (Julian days 180 through 230). In terms of daily maximum temperature fluctuation, therefore, the summer season is the most stable. Similarly, a relatively smooth and gradual seasonal variation of the average minimum temperature is illustrated by the relatively smooth standard deviation curve (Figure 6.3-41). The average daily minimum temperature appears to be least stable in the winter, with a range of approximately plus or minus 4°C to 5.5°C. The least day-to-day fluctuations (most stable) in daily minimum temperatures appear during the summer (Julian days 190 through 220), in the more narrow range of plus or minus 1.5°C to 2.5°C.



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

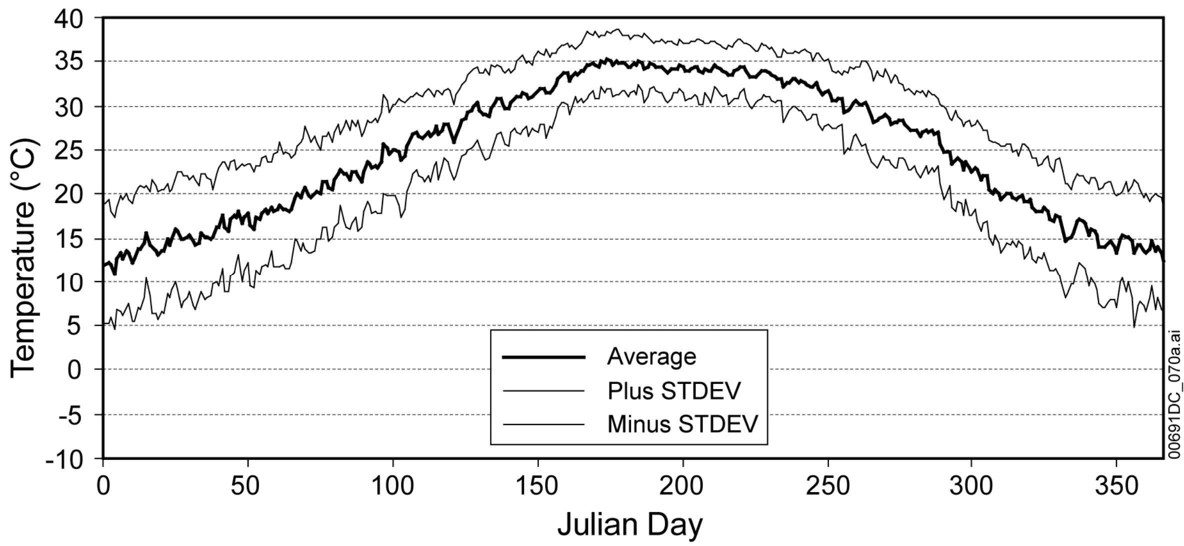
Figure 6.3-38. Daily Maximum Temperatures Recorded at Hobbs, New Mexico (1947 through 2004)



Source: See Appendix F.

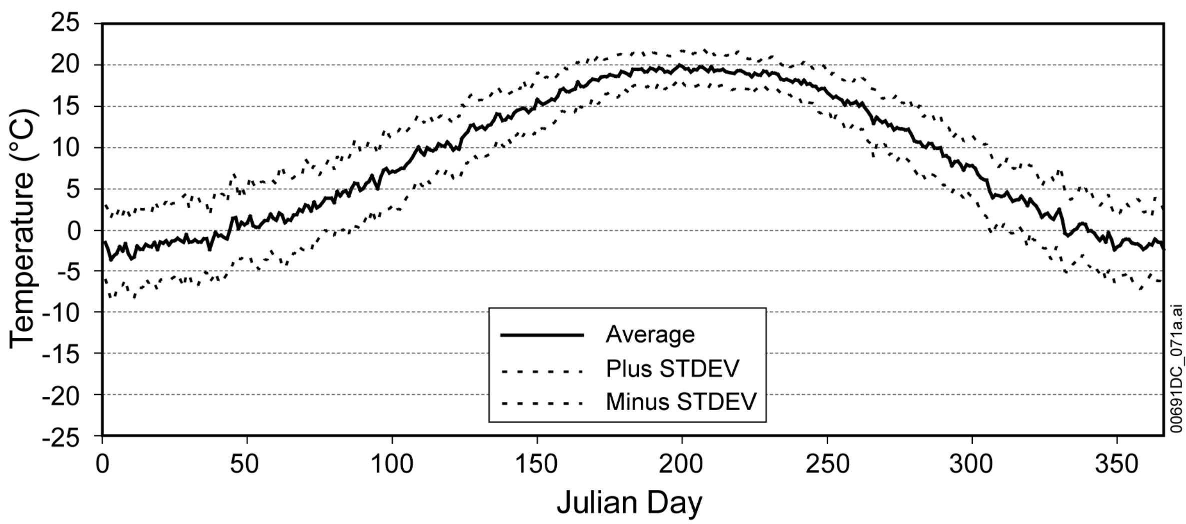
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-39. Daily Minimum Temperatures Recorded at Hobbs, New Mexico (1947 through 2004)



Source: See Appendix F.

Figure 6.3-40. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Hobbs, New Mexico (1947 through 2004)



Source: See Appendix F.

Figure 6.3-41. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Hobbs, New Mexico (1947 through 2004)

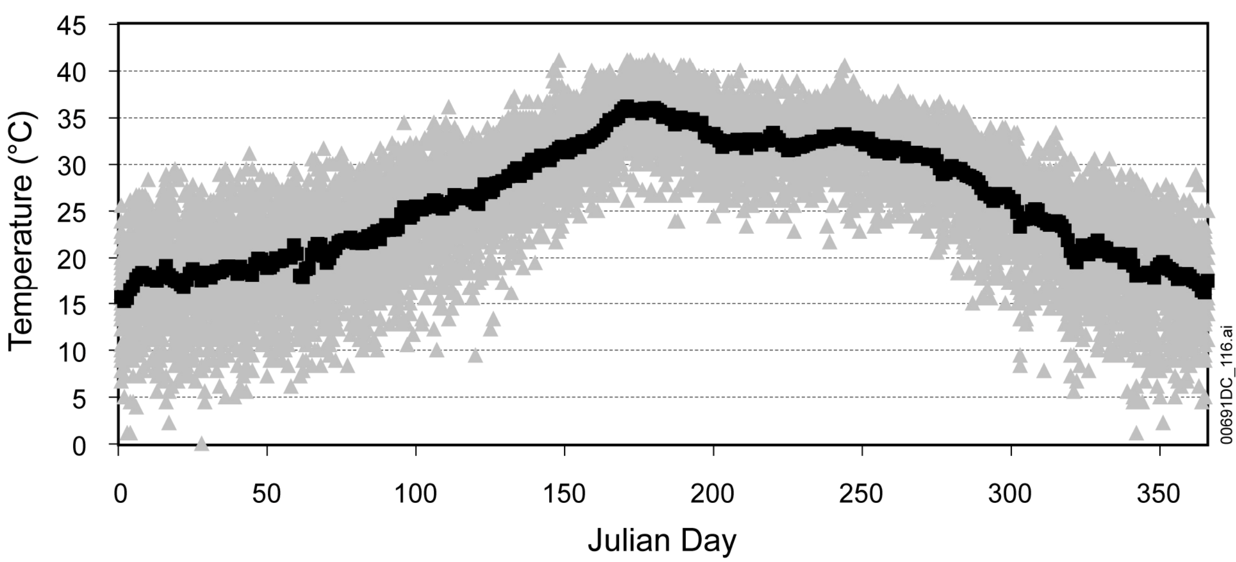
6.3.5.2.4 Nogales, Arizona

Daily maximum and minimum temperatures recorded at Nogales, Arizona, for the period of 1948 through 1982, are plotted in Figures 6.3-42 and 6.3-43. Average minimum and maximum temperatures plus or minus one standard deviation are plotted in Figures 6.3-44 and 6.3-45. The overall trend reflects the standard seasonal temperature profile.

The average annual maximum temperature varies between 11°C and 36.2°C, peaking on or about Julian day 171, after a gradual upward trend that begins around the first of the year

(Figure 6.3-44). After the early summer peak, a downward trend begins, but at a more gradual rate. The downward trend then levels off, and the temperature comes to a secondary peak of approximately 33°C around Julian days 245 to 250. A gradual descent then resumes until the end of the year, dropping to the average minimum temperature, −5.6°C, on approximately Julian day 4. The average minimum daily temperature profile is similar to the average maximum daily temperature profile, except there is no secondary peak, and is instead a very gradual decrease until Julian days 250 to 255, at which time occurs a more rapid decreasing trend toward fall and winter.

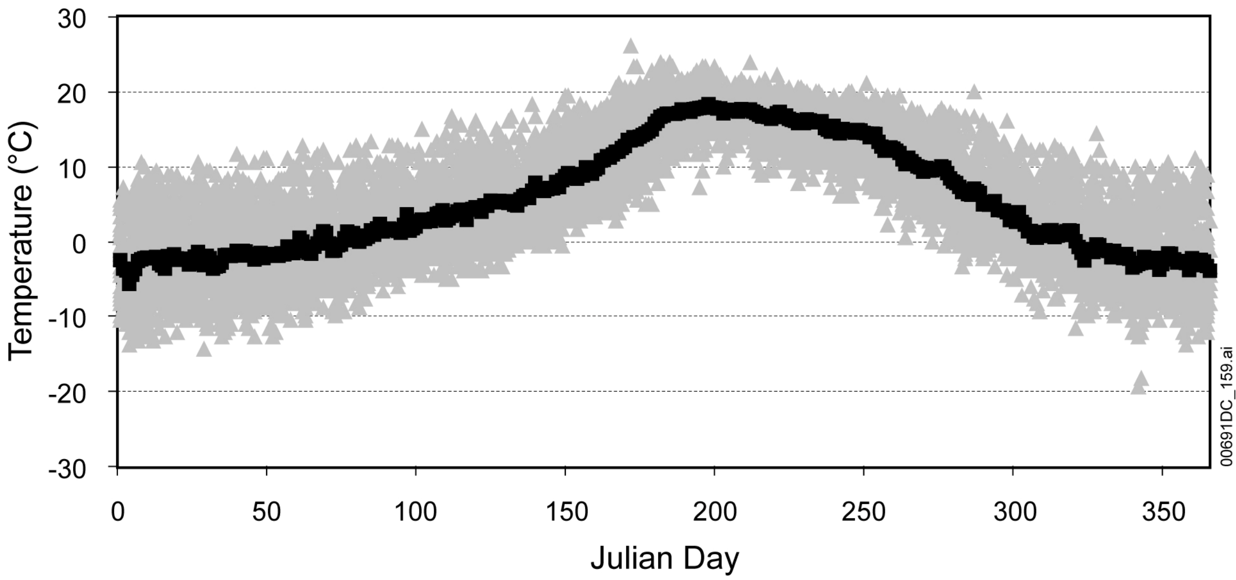
The standard deviation of the average maximum temperature depicts a relatively gradual decrease from winter to summer and back to winter (Figure 6.3-44). A standard deviation range of plus or minus 4°C to 5.5°C (relatively unstable) occurs in the late fall through early winter period (Julian days 325 through 50). The standard deviation then tends to decrease (become more stable), to a minimum range of approximately plus or minus 2°C to 3°C in mid-to-late summer (Julian days 220 through 250). After this period, the standard deviation again begins to increase until it reaches the maximum range of plus or minus 4°C to 5.5°C in the fall. In terms of daily maximum temperature fluctuation, therefore, the summer season is the most stable. Similarly, a review of one standard deviation above and below the average minimum temperature indicates a relatively smooth and gradual seasonal decline in the standard deviation (Figure 6.3-45), with a range of plus or minus 4°C to 5°C in January, to plus or minus 3°C to 4°C on approximately Julian day 180. The standard deviation range then abruptly decreases to a minimum (relatively stable) of plus or minus 1.5°C to 2°C approximately between Julian days 200 and 210. The standard deviation trend then again increases to the range of plus or minus 4°C to 5°C at the end of the fall.



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

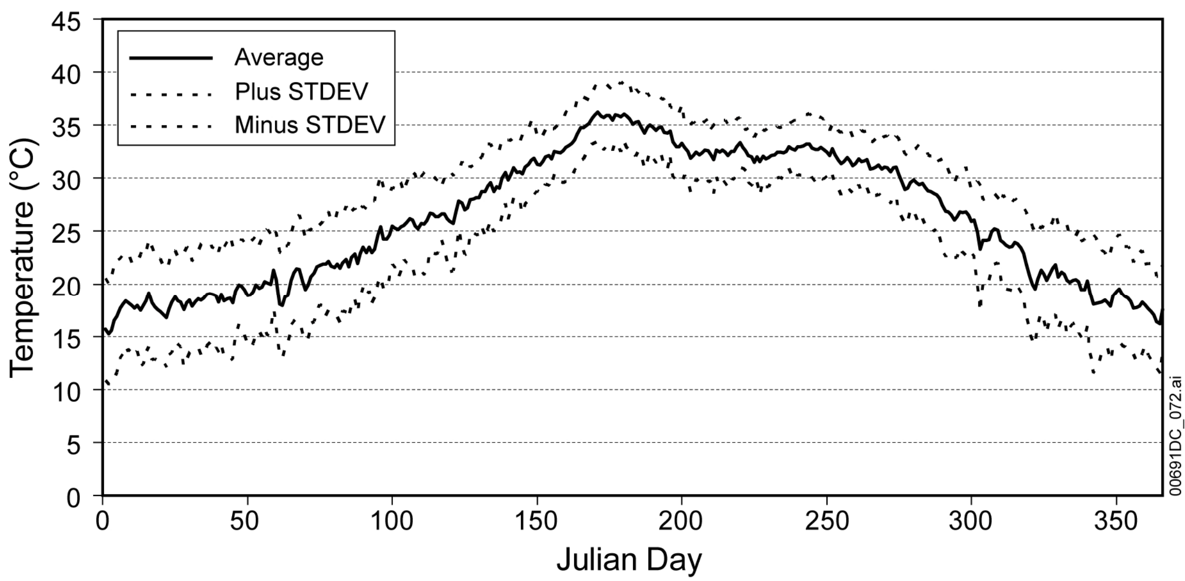
Figure 6.3-42. Daily Maximum Temperatures Recorded at Nogales, Arizona (1948 through 1983)



Source: See Appendix F.

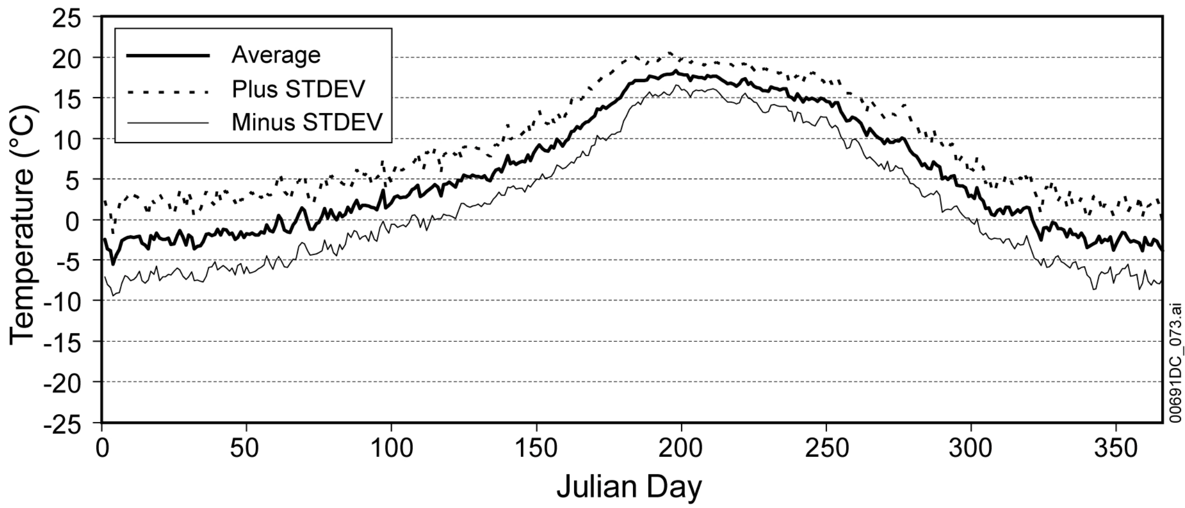
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-43. Average Annual Daily Minimum Temperatures Recorded at Nogales, Arizona (1948 through 1983)



Source: See Appendix F.

Figure 6.3-44. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Nogales, Arizona (1948 through 1983)



Source: See Appendix F.

Figure 6.3-45. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Nogales, Arizona (1948 through 1983)

6.3.5.2.5 Spokane, Washington

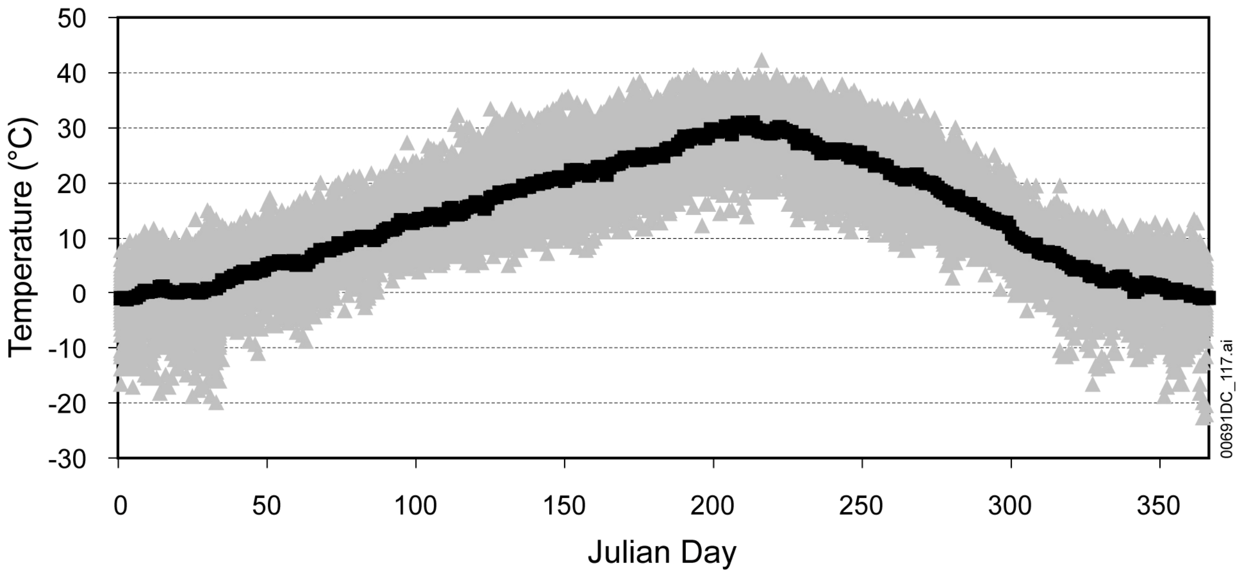
Daily maximum and minimum temperatures recorded at Spokane, Washington, for the period 1948 through 2004, are plotted in Figures 6.3-46 and 6.3-47. Average minimum and maximum temperature plus or minus one standard deviation are plotted in Figures 6.3-48 and 6.3-49. The overall trend reflects the standard seasonal temperature profile.

The average annual maximum temperature varies between −1°C and 31°C, peaking on or about Julian day 210, after a gradual upward trend that begins around the first of the year (Figure 6.3-48). After the early summer peak, a downward trend begins, but at a more gradual rate, dropping to the average annual minimum temperature of −7.7°C about Julian day 5. The average minimum daily temperature profile is similar to the average maximum daily temperature, but with an average annual range of −7.7°C to 14.3°C.

The average maximum temperature depicts a pulsating standard deviation range throughout the year (Figure 6.3-48). The range begins at approximately plus or minus 4°C to 6°C in winter, and decreases to approximately plus or minus 3.5°C to 4.5°C near Julian day 75. The trend then reverses, with the range increasing to approximately 5°C to 6°C by day 150. Reversing again, the range decreases to approximately plus or minus 4°C to 5°C near Julian days 205 through 220. Another reverse in the standard deviation trend takes the range back to plus or minus 5°C to 6°C near Julian days 265 through 270. Again, the trend reverses by returning to the range of plus or minus 3°C to 4.5°C over the period of Julian days 290 through 315. The trend then increases to a range of plus or minus 4°C to 6°C by Julian day 360. In terms of temperature fluctuations from one day to the next, therefore, early spring, midsummer, and mid-fall seem to be the most stable.

The average minimum temperature, plus and minus one standard deviation, reflects a variability in temperature fluctuation (Figure 6.3-49) similar to that of the maximum temperature

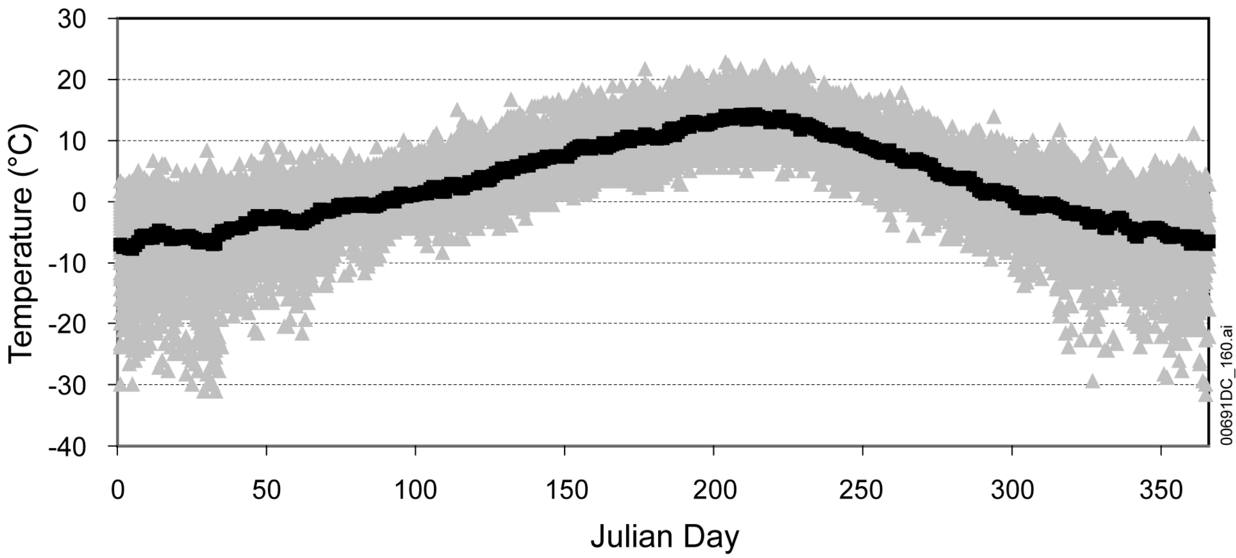
(Figure 6.3-48). However, the average minimum temperature plot reflects a more gradual trend from higher standard deviation values in the range of plus or minus 6°C to 7.5°C in winter, to a minimum "plateau" in the range of plus or minus 2.5°C to 4°C from Julian day 80 to 280. This 200-day period lasts from the first day of spring through mid-fall, before increasing to the wider standard deviation of plus or minus 6°C to 7.5°C by winter. This long period of stability in minimum temperature change may indicate a stable atmosphere with few perturbations during early morning hours.



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

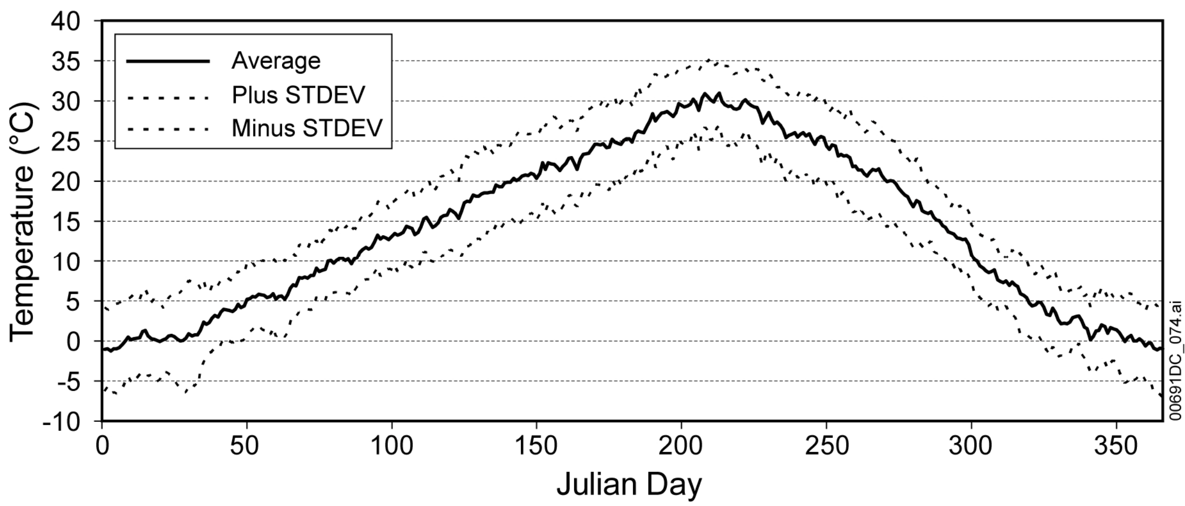
Figure 6.3-46. Daily Maximum Temperatures Recorded at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

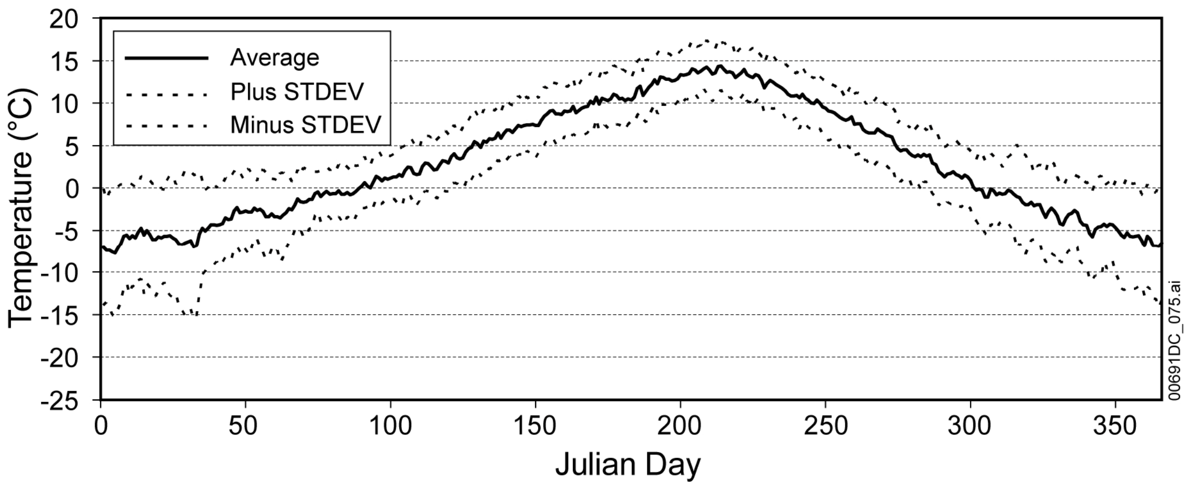
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-47. Daily Minimum Temperatures Recorded at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

Figure 6.3-48. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Spokane, Washington (1948 through 2004)



Source: See Appendix F.

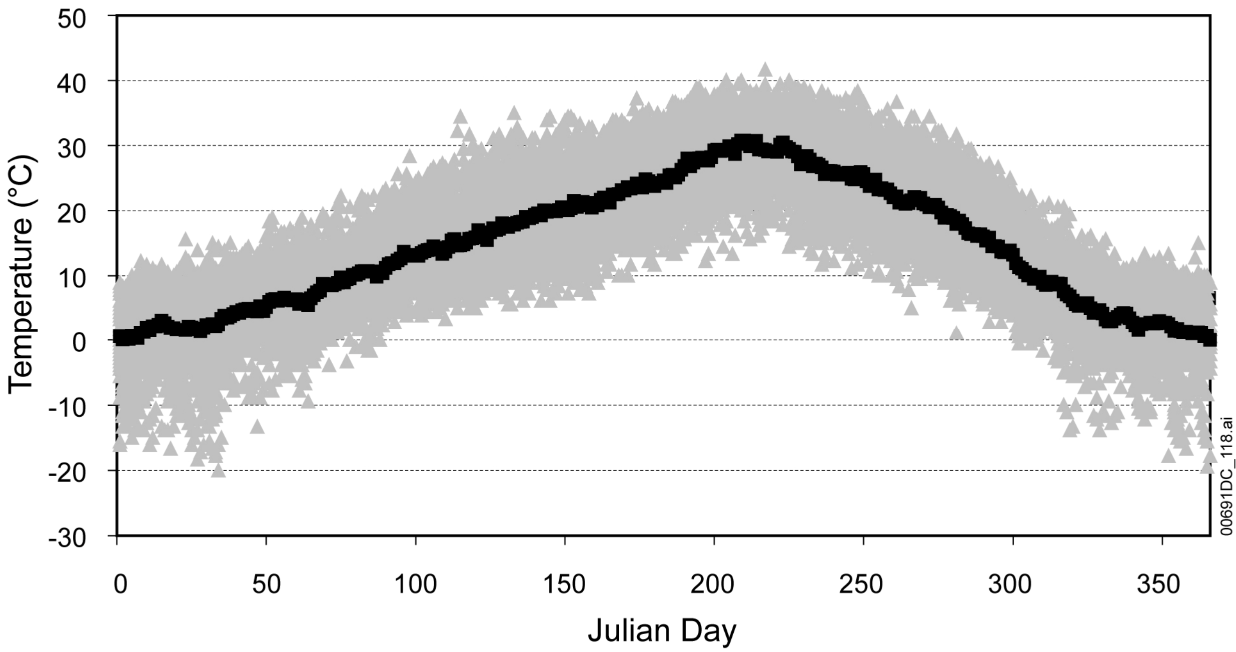
Figure 6.3-49. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Spokane, Washington (1948 through 2004)

6.3.5.2.6 Rosalia, Washington

Daily maximum and minimum temperatures recorded at Rosalia, Washington, for the period 1949 through 2004, are plotted in Figures 6.3-50 and 6.3-51. Average minimum and maximum temperatures plus or minus one standard deviation are plotted in Figures 6.3-52 and 6.3-53. The overall trend reflects the standard seasonal temperature profile.

The average annual maximum temperature varies between −6.3°C and 30.8°C, peaking on or about Julian day 209, after a gradual upward trend that begins around the first of the year (Figure 6.3-52). After the early summer peak, a downward trend begins, but at a steeper rate relative to the first half of the year, dropping to the average annual minimum temperature of −6.9°C on approximately Julian day 2. The average minimum daily temperature profile is similar to the average maximum daily temperature, but with an average annual range of −6.9°C to 11.9°C.

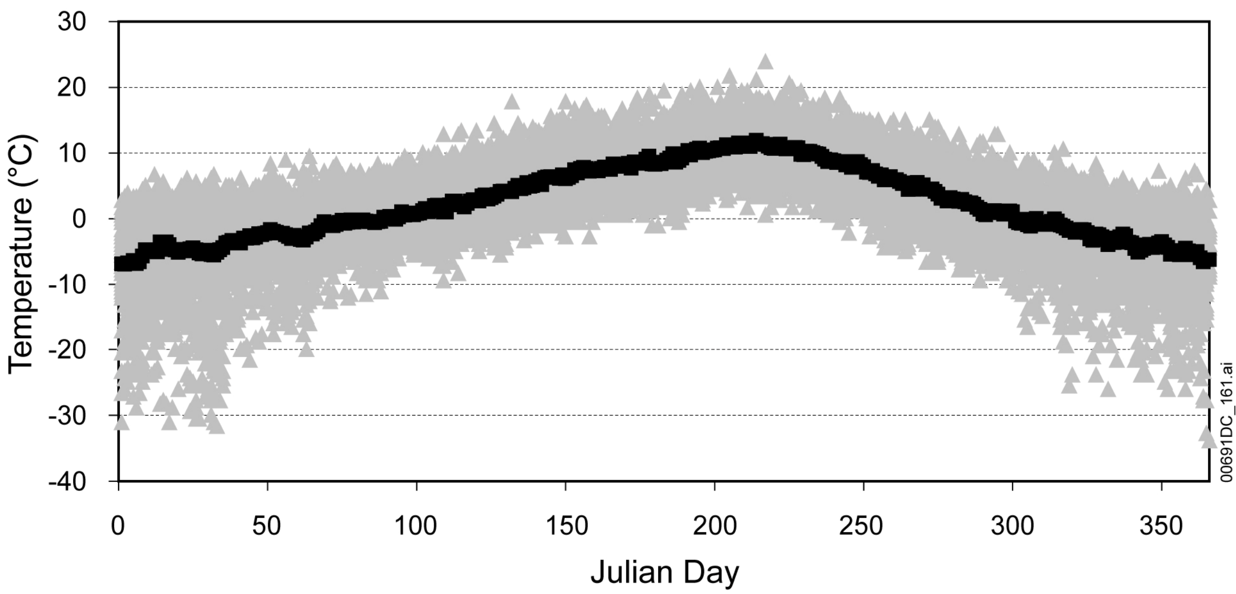
The standard deviation varies approximately 4°C to 6.5°C in winter, and decreases to approximately plus or minus 3.5°C to 5°C from Julian days 70 through 80 (Figures 6.3-52 and 6.3-53). The trend then reverses, with the range increasing to approximately plus or minus 4.5°C to 6°C by Julian days 145 through 155. The range then decreases to approximately plus or minus 4°C to 5°C near Julian day 205. Another reverse in the standard deviation trend takes the range to approximately plus or minus 5°C to 6.5°C near Julian days 265 through 280. The trend then reverses by returning to the range of plus or minus 3°C to 5°C over Julian days 310 through 335, and then increases to a range of plus or minus 4°C to 6°C by Julian day 360. In terms of temperature fluctuations from one day to the next, therefore, early spring, midsummer, and mid-fall seem to be the most stable. This trend is similar to the trend in the Spokane profile (Figures 6.3-48 and 6.3-49).



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

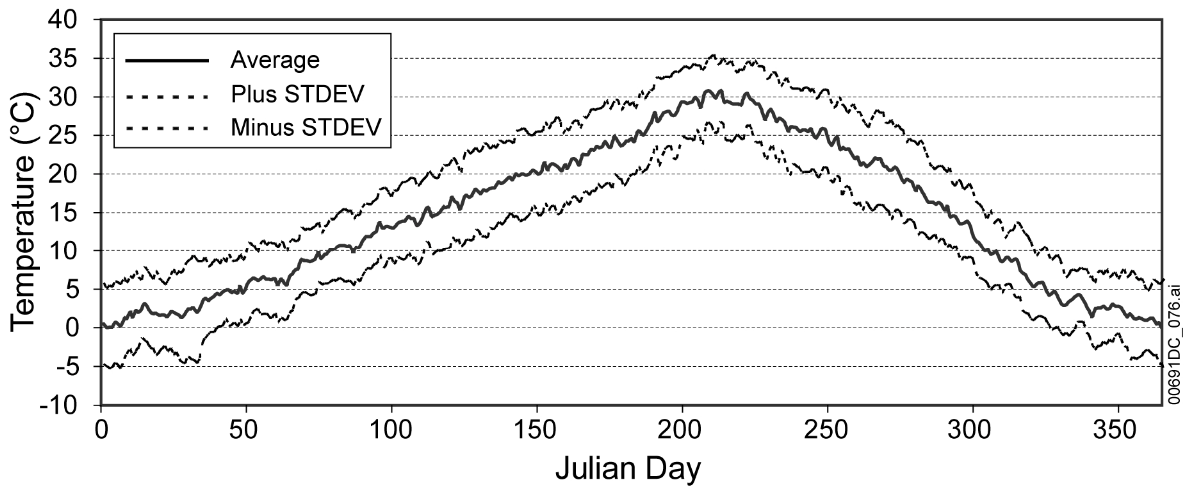
Figure 6.3-50. Daily Maximum Temperatures Recorded at Rosalia, Washington (1949 through 2004)



Source: See Appendix F.

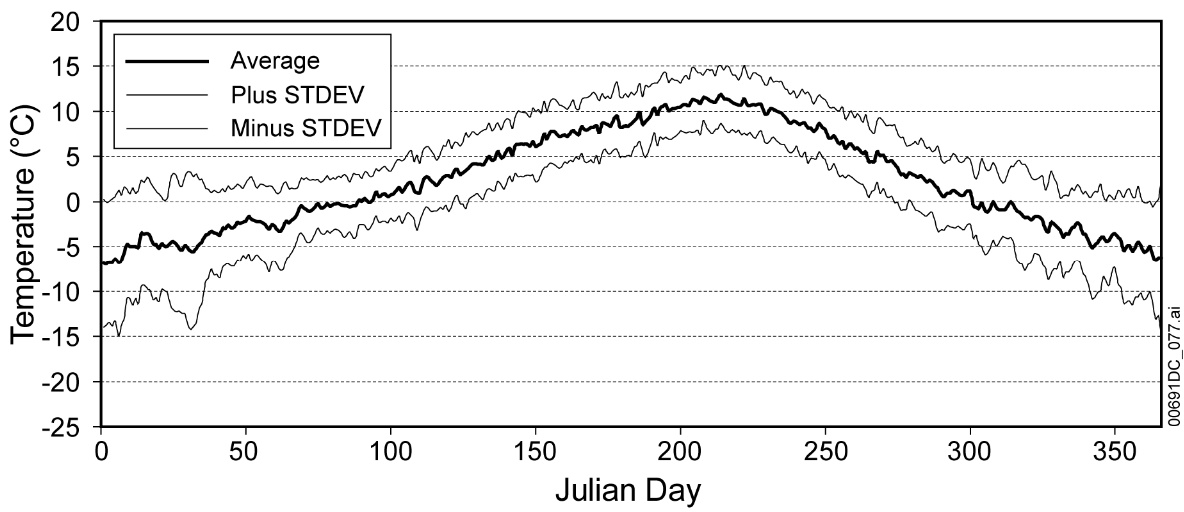
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-51. Daily Minimum Temperatures Recorded at Rosalia, Washington (1949 through 2004)



Source: See Appendix F.

Figure 6.3-52. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Rosalia, Washington (1951 through 2004)



Source: See Appendix F.

Figure 6.3-53. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Rosalia, Washington (1951 through 2004)

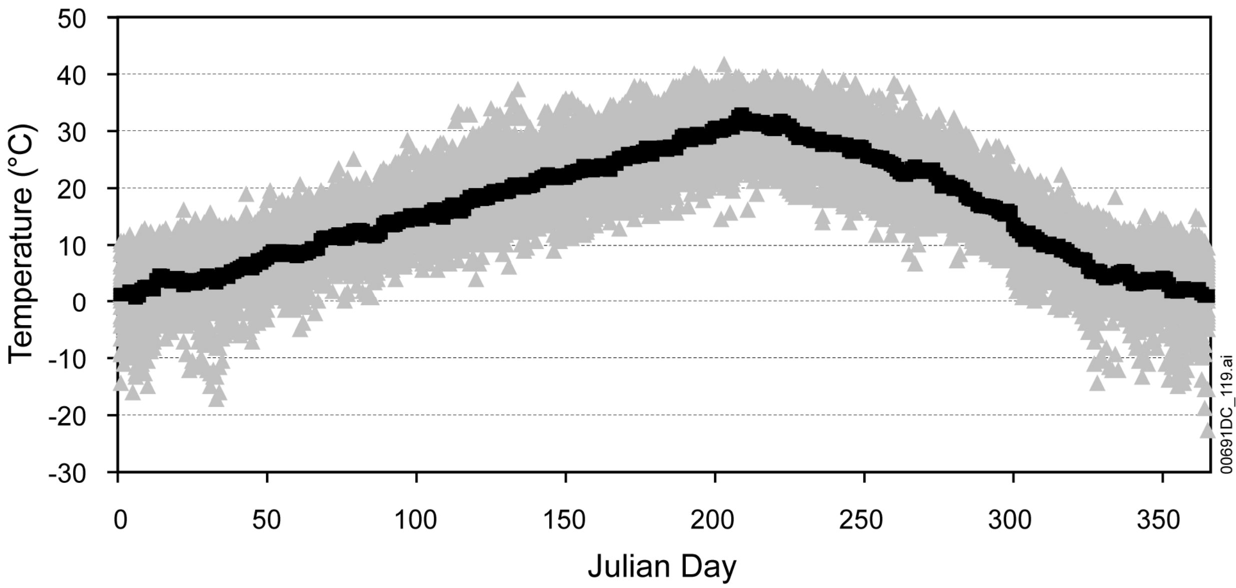
6.3.5.2.7 St. John, Washington

Daily maximum and minimum temperatures recorded at St. John, Washington, for the period of 1963 through 2004, are plotted in Figures 6.3-54 and 6.3-55. Average minimum and maximum temperature plus or minus one standard deviation are plotted in Figures 6.3-56 and 6.3-57. The overall trend reflects the standard seasonal temperature profile.

The average annual maximum temperature varies between 0.6°C and 32.8°C, peaking on or about Julian day 209, after a very gradual upward trend that begins around the first of the year (Figure 6.3-56). After the early summer peak, a downward trend begins, but at a steeper rate relative to the first half of the year, dropping to the average annual minimum temperature of −6.9°C on approximately Julian day 2. The average minimum daily temperature profile is similar to the average maximum daily temperature, but with an average annual range of −7.0°C to 11.7°C.

Throughout the year, a pulsating standard deviation range exists for daily maximum temperature. The range begins at approximately plus or minus 3.5°C to 6.5°C in winter, and decreases to approximately plus or minus 3.5°C to 4.5°C near Julian day 70 (Figure 6.3-56). The trend then reverses, the range increasing to approximately plus or minus 5°C to 6°C by Julian days 120 through 130. The range then decreases to approximately plus or minus 3.5°C to 5°C over the period ending near Julian days 205 through 210. Another reverse in the standard deviation trend then takes the range back to plus or minus 5°C to 6°C near Julian days 265 through 280. The trend then returns to the range of plus or minus 3.5°C to 5°C over Julian days 300 through 350. The trend then increases to a range of plus or minus 4.5°C to 6°C by Julian day 360. In terms of temperature fluctuations from one day to the next, therefore, early spring, midsummer, and mid-fall seem to be the most stable. This is similar to the profiles of Spokane (Figure 6.3-48) and Rosalia (Figure 6.3-52).

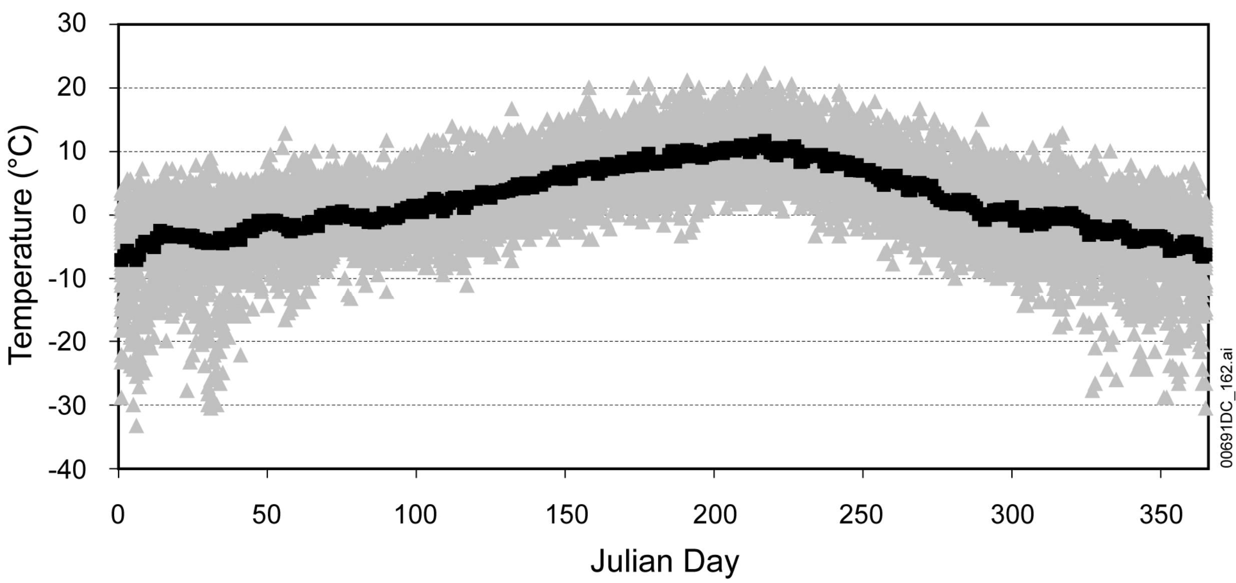
The same variability in temperature fluctuation depicted for annual daily maximum temperature (Figure 6.3-56) is not reflected in the trend for annual daily minimum temperature (Figure 6.3-57). The average minimum temperature reflects a more gradual trend from higher standard deviation values of plus or minus 4°C to 9°C in winter, to a minimum “plateau” in the range of plus or minus 3°C to 5°C, occurring from Julian day 50 to 250. This 200-day period lasts from mid-February through early September; the average minimum temperature then increases to the wider standard deviation of plus or minus 5°C to 8°C by early winter. This long period of stability in minimum temperature change may indicate a stable atmosphere with few perturbations during early morning hours. This profile is very similar to that of Spokane (Figure 6.3-49) and Rosalia (Figure 6.3-53).



Source: See Appendix F.

NOTE: The black symbols indicate the daily average maximum temperature for the reference period.

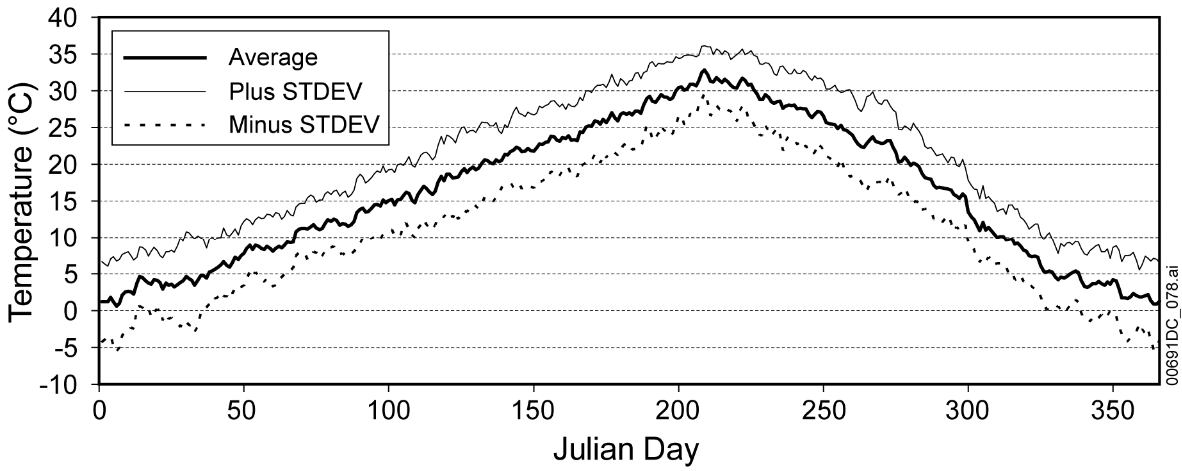
Figure 6.3-54. Daily Maximum Temperatures Recorded at St. John, Washington (1964 through 2004)



Source: See Appendix F.

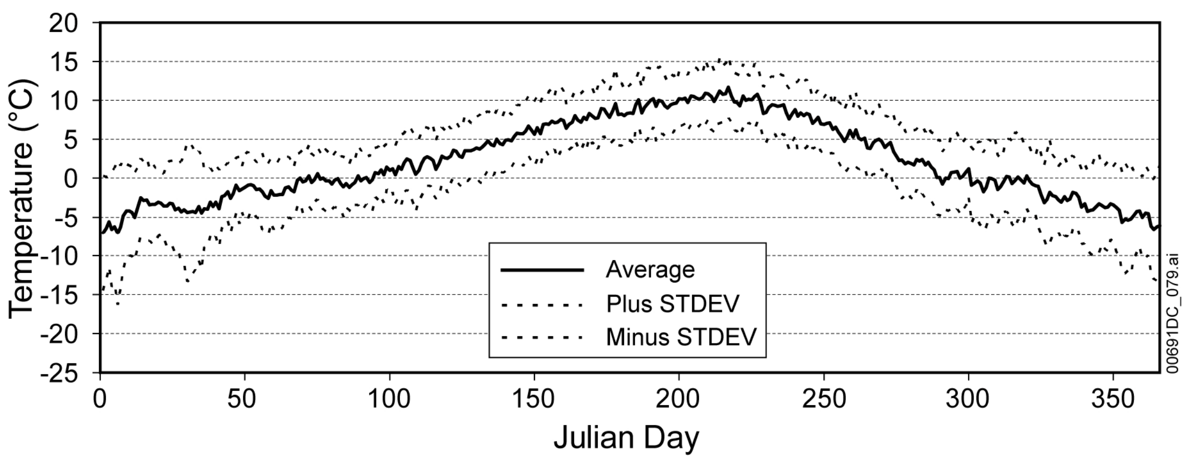
NOTE: The black symbols indicate the daily average minimum temperature for the reference period.

Figure 6.3-55. Daily Minimum Temperatures Recorded at St. John, Washington (1963 through 2004)



Source: See Appendix F.

Figure 6.3-56. Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at St. John, Washington (1963 through 2004)



Source: See Appendix F.

Figure 6.3-57. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at St. John, Washington (1963 through 2004)

6.4 TEMPERATURE DATA FROM METEOROLOGICAL DATA ACQUISITION STATIONS LOCATED WITHIN THE NEVADA TEST SITE AND REPRESENTATIVE OF PRESENT-DAY CLIMATE CONDITIONS

For the purposes of infiltration modeling, it is beneficial to have the air temperature data for the period, and the same location as a precipitation event. The Area 12 and Site 4JA precipitation stations (Section 6.3) are NOAA stations, located on the NTS, that do not record temperature data. Consequently, it is necessary to locate temperature data obtained from nearby sources that coincide with Area 12 and Site 4JA precipitation data. There are numerous MEDA stations on the NTS that recorded temperature values during the same timeframe as the precipitation recorded for Area 12 and Site 4JA. Two stations, MEDA 12 and MEDA 26, were selected to provide temperature data representative of Area 12 and Site 4JA temperatures. The two MEDA stations were selected because of their close proximity to Area 12 and Site 4JA and, thus, are indicative of local minimum, maximum, and average temperatures measured within the vicinities of the precipitation stations.

Temperature data from MEDA 12 were selected to coincide with Area 12 data; Area 12 is less than 1 km from MEDA 12. Temperature data from MEDA 26 were selected to coincide with precipitation data from Site 4JA; MEDA 26 is located approximately 5 km northeast of Site 4JA. MEDA 12 and MEDA 26 temperature data are unqualified. These unqualified temperature data for the two stations are captured in DTN: SN0603NTSMEDAW.001 [DIRS 176721]. The 15-minute interval data in DTN: SN0603NTSMEDAW.002 are qualified in Appendix A. The qualification status of the data is solely for use in this report, and has been used to derive summary temperature data from the 15-minute values. The summary temperature data are the calculated daily values of minimum, maximum, and average temperature values at MEDA 12 and MEDA 26. The daily temperature data were calculated as part of the qualification process, and were transferred to output DTN: SN0603TEMPMEDA.002.

6.4.1 Data Processing and Extraction

The temperature data in DTN: SN0603NTSMEDAW.001 are contained in two Excel® workbooks, *MEDA12_15 Minute UnQTemperature Jan93_Dec04.xls* and *MEDA 26 UnQ Temperature93_04 Mar16.xls*. Each workbook consists of 12 worksheets that contain the 15-minute interval temperature data; one worksheet exists for each year of data. Each worksheet contains temperature readings for an entire year, in 15-minute intervals.

Because temperature data in DTN: SN0603NTSMEDAW.001 [DIRS 176721] are given over 15-minute intervals, there are 96 temperature readings per day. On many days, an “n/a” was recorded for some 15-minute temperature intervals . It was decided that if, on any one specific day, there were error notations for five or more hours, denoted by at least 20 “n/a” flags, then insufficient 15-minute temperature values existed to derive a daily summary temperature value. In these instances, no daily minimum, maximum, or average temperature values were transferred to temperature summary worksheets. Instead, “n/a” was listed to indicate erroneous summary temperature values for that day.

Errors in source data are denoted with dashes (-), or fields of “9999” or “−9999.” Many error designators have been replaced in DTN: SN0603NTSMEDAW.001 with an “n/a” designator. To ensure the replacement of dashes, and fields with “9999” or “−9999” designators, with the “n/a” designator, the Excel® SEARCH and REPLACE functions were invoked. After ensuring that 9999s and dashes were removed, the daily average, minimum, and maximum temperature values were determined.

Using the Excel® AVERAGE function, daily averages were computed on each yearly worksheet from the extracted 15-minute values, and were pasted into the preliminary workbooks *MEDA 26 Preliminary Summary_93_04.xls* and *MEDA 12 Preliminary Summary_93_04.xls* for analysis during the qualification process. Using the Excel® MIN and MAX functions, minimum and maximum daily temperatures, over 24-hour daily periods, were calculated from the extracted 15-minute interval data.

The computed average, minimum, and maximum temperature values were placed in columns to the left of the source data in the preliminary workbooks, which were then transferred to summary worksheets after qualification.

6.4.2 Internal Checking

Data were internally checked to ensure proper transfers and screening, which included the following steps:

1. If five or more hours of "n/a" designators were recorded per day, then any minimum, maximum, or average temperature values for that day were not calculated or transferred to summary worksheets.

2. A check was performed to ensure data were correctly transmitted from that listed on the yearly 15-minute worksheets to the corresponding element of the summary worksheets.

3. An entry was included for the 366th day of each year, as appropriate.

6.4.3 Output Meteorological Data Acquisition Temperature Data Used for Present-Day Climate Conditions

Temperature data in output DTN: SN0603TEMPMEDA.002 are contained in two Excel® workbooks:

- *MEDA12_Temperature_Summary_1993-2004_Mar27.xls*
- *MEDA26_Temperature_Summary_1993-2004_Mar27.xls.*

Worksheets within each workbook containing average, minimum, and maximum temperature data are identified in Table 6.4-1.

Temperature data in output DTN: SN0603TEMPMEDA.002 consist of daily values of minimum, maximum, and average temperature values, denoted in this document as MEDA summary temperature data. Worksheets containing qualified MEDA summary temperature data are listed in Table 6.4-1.

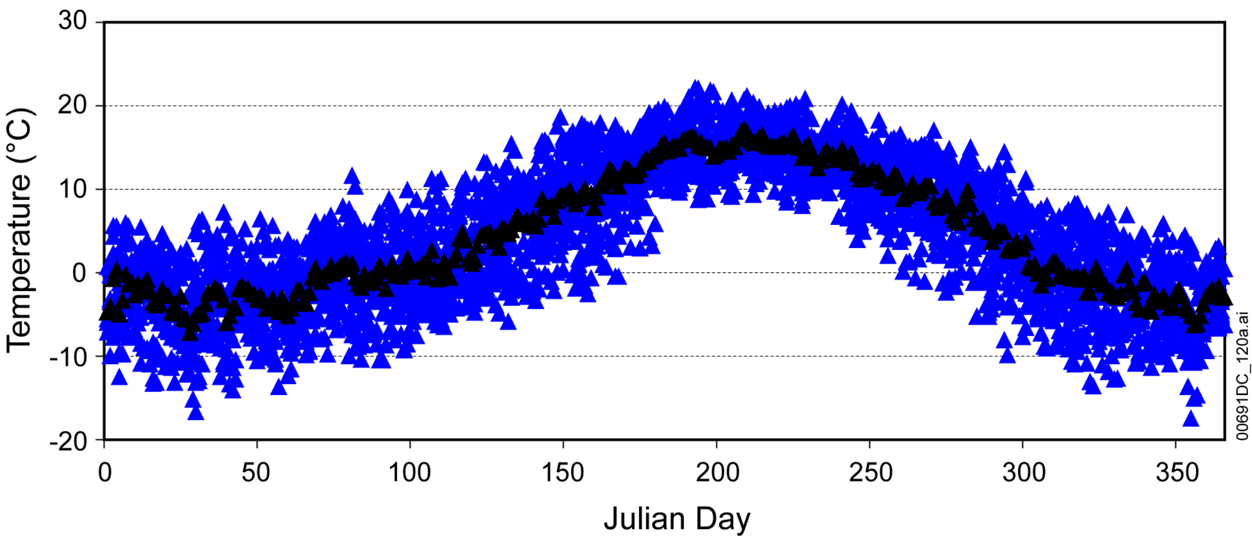
Table 6.4-1. Worksheets Containing MEDA Summary Temperature Data

Summary Worksheet Name	Units	Calculated 24-hour Daily Values Using 15-minute Inputs
Daily AvgTemp	degrees Celsius	Average daily ambient air temperature
Daily MaxTemp	degrees Celsius	Maximum daily temperature
Daily MinTemp	degrees Celsius	Minimum daily temperature

Source: Output DTN: SN0603TEMPMEDA.002.

6.4.4 MEDA 12 and MEDA 26 Maximum and Minimum Temperatures

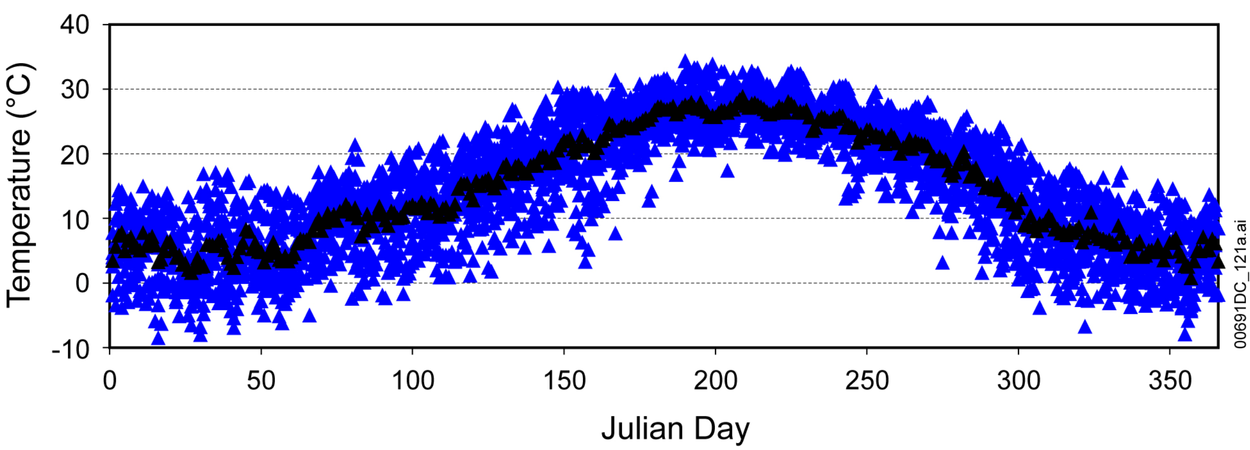
Plotted minimum and maximum daily temperatures at MEDA 12 and at MEDA 26 are shown in Figures 6.4-1 and 6.4-2. Average minimum and maximum temperature for the 12-year period of 1993 to 2004 were plotted to identify patterns and trends, and were overlaid by the standard deviation for both minimum and maximum temperature (Figures 6.4-3 and 6.4-4 for MEDA 12, and Figures 6.4-5 and 6.4-6 for MEDA 26).



Source: See Appendix F.

NOTE: The black symbols denote an average minimum daily temperature for the reference period.

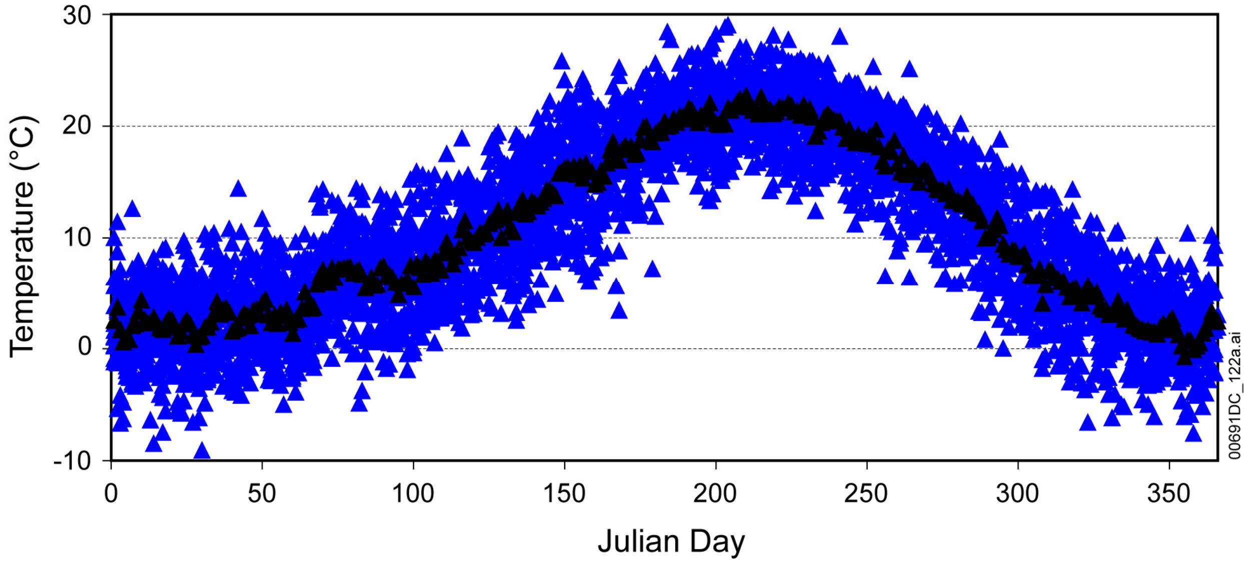
Figure 6.4-1a. Minimum Daily Temperature Recorded at MEDA 12 (1993 through 2004)



Source: See Appendix F.

NOTE: The black symbols denote an average maximum daily temperature for the reference period.

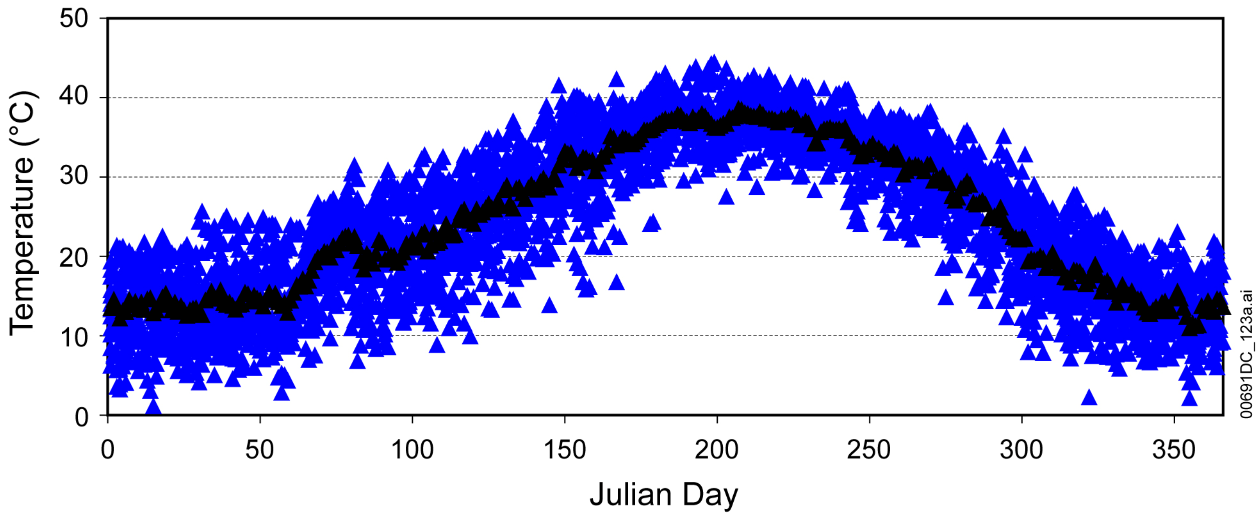
Figure 6.4-1b. Maximum Daily Temperature Recorded at MEDA 12 (1993 through 2004)



Source: See Appendix F.

NOTE: The black symbols denote an average minimum daily temperature for the reference period.

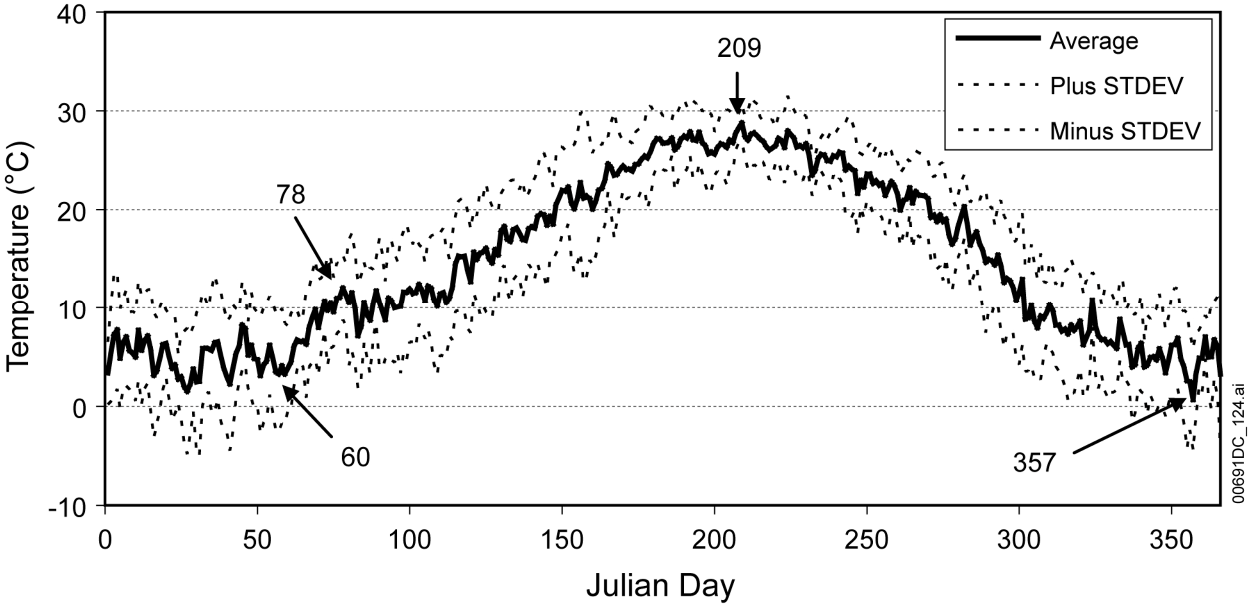
Figure 6.4-2a. Minimum Daily Temperature Recorded at MEDA 26 (1993 through 2004)



Source: See Appendix F.

NOTE: The black symbols denote an average maximum daily temperature for the reference period.

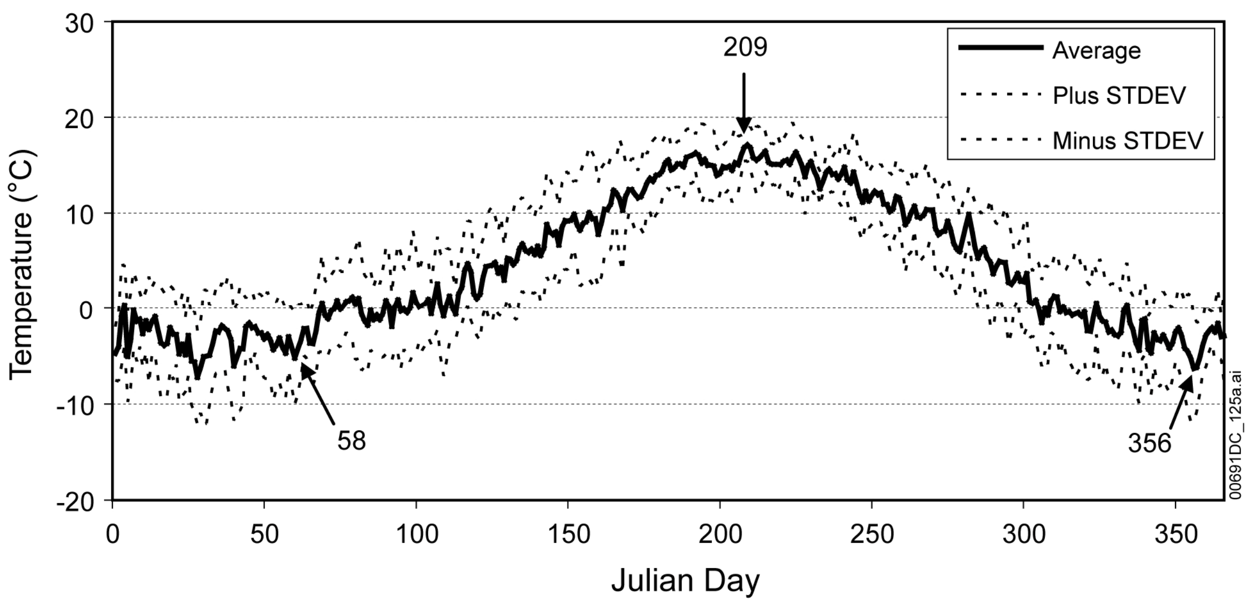
Figure 6.4-2b. Maximum Daily Temperature Recorded at MEDA 26 (1993 through 2004)



Source: See Appendix F.

NOTE: Arrows indicate the approximate days when temperature reaches minimum or maximum value, or a seasonal transition.

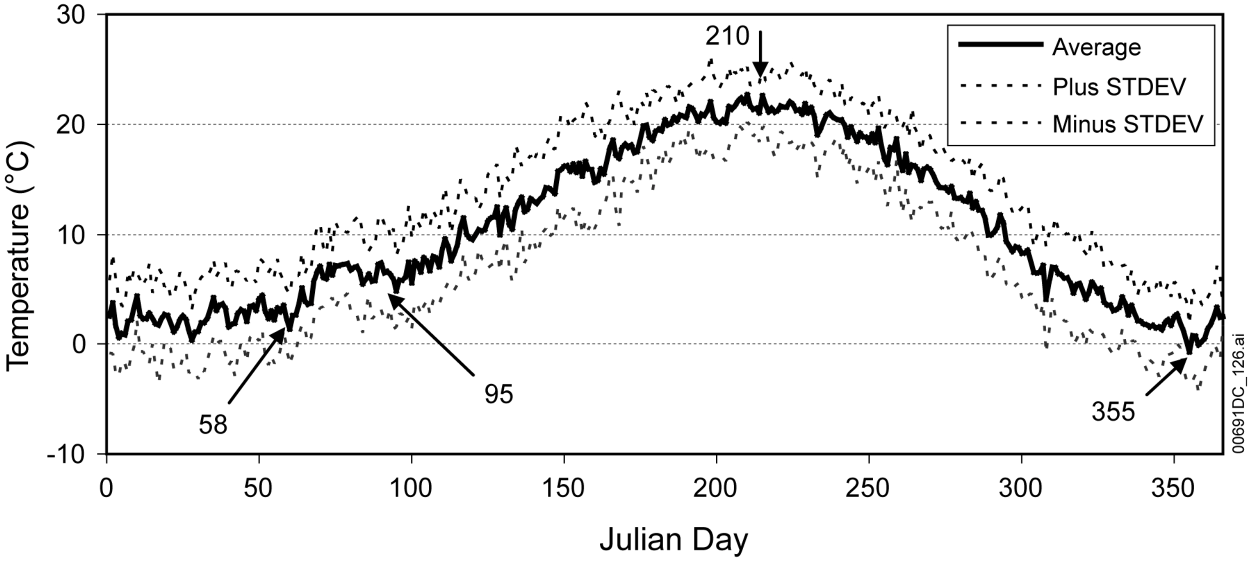
Figure 6.4-3. Maximum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 12 (1993 through 2004)



Source: See Appendix F.

NOTE: Arrows indicate the approximate days when temperature reaches minimum or maximum value, or a seasonal transition.

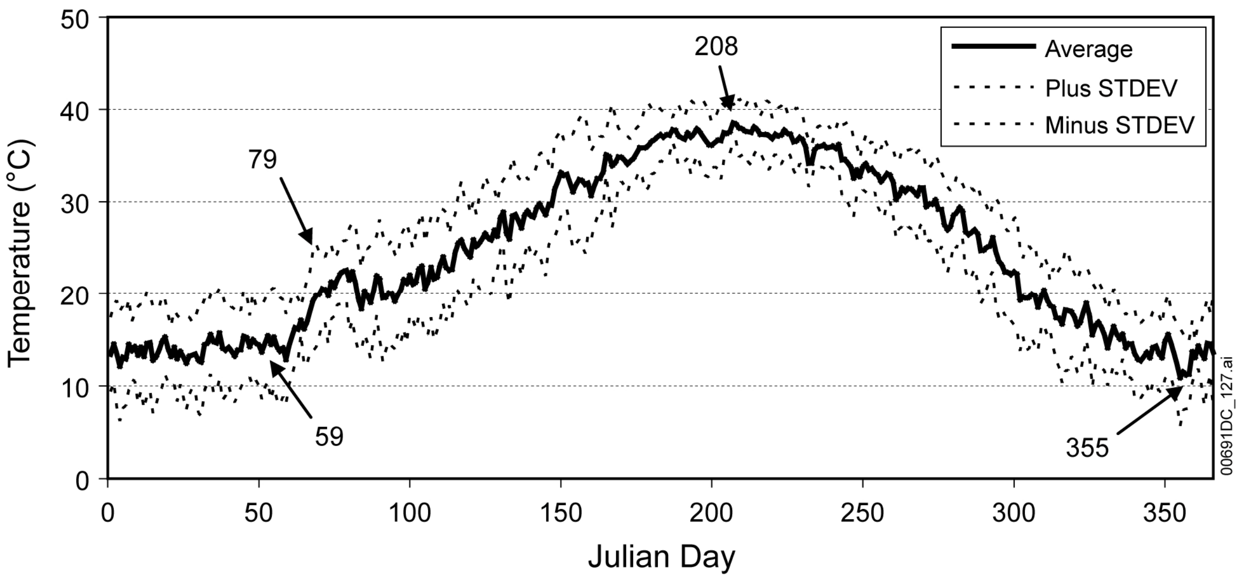
Figure 6.4-4. Minimum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 12 (1993 through 2004)



Source: See Appendix F.

NOTE: Arrows indicate the approximate days when temperature reaches minimum or maximum value, or a seasonal transition.

Figure 6.4-5. Maximum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 26 (1993 through 2004)



Source: See Appendix F.

NOTE: Arrows indicate the approximate days when temperature reaches minimum or maximum value, or a seasonal transition.

Figure 6.4-6. Minimum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 26 (1993 through 2004)

At both locations, similar temperatures occur during two timeframes of relative temperature stability that last between 40 to 60 days, when maximum and minimum temperature remain within a five-degree range. One such timeframe occurs during the hottest days of the year, around Julian days 185 through 226; the other occurs around the coldest days of the year, Julian days 355 through 60. These occurrences are referred to herein as temperature plateaus. Inflection points are seen on the temperature curves when temperature transitions from one characteristic period to another.

Temperature patterns and location of inflection points recorded at MEDA 12 and MEDA 26 are summarized as follows:

- Around Julian days 59 or 60, both minimum and maximum temperature transition from a relatively steady and narrow oscillatory period to a time when days experience a sharp and progressive temperature increase. This period lasts for about 20 days terminating around Julian day 80.

- For a brief 15-day period, beginning around Julian days 80 or 81, temperatures transition out of a phase in which they have been rapidly increasing, to a short phase in which they remain relatively constant or slightly decline. This period ends around Julian day 95.

- Around Julian days 95 or 96, both minimum and maximum temperatures begin to transition into a period in which they progressively increase. This steady rise lasts for approximately 94 or 95 days and persists up to Julian days 189 or 190.

- Temperature values plateau between Julian days 189 and 190 through 228 and 229. During this period, minimum and maximum temperatures generally do not vary by more than a few degrees. This temperature plateau persists for approximately 40 days. During the high temperature plateau, a temperature maximum occurs around Julian day 208 or 209.

- Around Julian day 229, daily temperature minima and maxima transition out of the time of relatively stability to one in which they begin to progressively decline. This declining trend continues for approximately 126 days, ending around Julian days 355 to 357. Within a few days of Julian day 355, temperature values reach their lowest point during the 365-day cycle.

- After Julian day 355 (plus or minus a day or two) temperature values transition from their steadily declining phase into one in which they oscillate within a narrow range. This lasts for or approximately 70 days, and is identified as a low temperature plateau.

The low temperature plateau is broken around Julian days 59 to 60, when temperature minima and maxima start to rapidly increase. This is the beginning of the cycle described in the first bullet.

7. CONCLUSION

The output of this analysis presents meteorological data suitable for use in developing a suite of meteorological parameters used as inputs to represent present-day and future climate conditions, and their estimated uncertainties, in the vicinity of Yucca Mountain.

Data used as inputs to represent present-day climatic conditions are discussed throughout Sections 6.1, 6.2, and 6.4. Present-day meteorological information was recorded and measured at meteorological stations within an approximate 40 km radius of Yucca Mountain. Data collected from these stations are from YM Sites 1, 2, 3, 6, and 9, operated by the Yucca Mountain Project, and from Amargosa Farms–Garey, Cane Springs, Area 12, Site 4JA, 40MN, MEDA 12, and MEDA 26, operated by NOAA and NOAA/ARL/SORD.

In addition, meteorological data from seven proxy future-climate locations are used throughout Section 6.3. The locations are: Beowawe, Nevada; Delta, Utah; Hobbs, New Mexico; Nogales, Arizona; Rosalia, Washington; Spokane, Washington; and St. John, Washington. These proxy locations represent monsoon and glacial transition climatic conditions predicted to occur in the vicinity of Yucca Mountain during the next 10,000 years (BSC 2004 [DIRS 170002]). Meteorological data from these proxy locations are also intended for use as inputs for generating future climate conditions and their respective uncertainties, within the vicinity of Yucca Mountain. The meteorological data from Nogales, Arizona, and from Hobbs, New Mexico, represent the upper-bound proxy monsoon condition at Yucca Mountain; the upper-bound glacial transition climate is represented by meteorological data from Rosalia, Spokane, and St. John, Washington. The lower bound-glacial transition climate is represented by meteorological data from Beowawe, Nevada, and from Delta, Utah.

Data from the proxy climate locations represent precipitation and temperature ranges at the top of Yucca Mountain. Adjustments for elevation should be made by the downstream user, as appropriate.

7.1 PRECIPITATION AND TEMPERATURE PARAMETERS

The meteorological parameters that the proxy-climate data represent are limited to the timeframes and locations from which the measurements were taken. The data cover timeframes that span 12 to 50 years (e.g., data from Rosalia and Spokane span a 50-year timeframe, data from Area 12 and Site 4JA span a 40-year timeframe). The shortest timeframe of 12 years are recorded at YM Sites 1, 2, 3, 6, and 9, and at MEDA 12 and MEDA 26. The longer timeframes of recorded data result in larger data distributions and, generally, larger differences between extreme values. With only a 12-year record, the data collected from YM Sites 1, 2, 3, 6, and 9, and at MEDA 12 and MEDA 26, have smaller differences between extreme values, and less variability than those data sets spanning a larger number of years. Therefore, given predicted meteorological conditions, data alone may not be a complete reflection of the variability or uncertainty that may arise. Any uncertainty in predicting present-day and future climate conditions that arises based on meteorological data provided herein must be addressed by the downstream user prior to use as appropriate.

Because precipitation is considered the source of surface infiltration, and because temperature is the meteorological parameter most affecting the relationship between precipitation and infiltration given in this data set, summaries of these two meteorological components are provided in the following paragraphs.

The temperature and precipitation data summarized are given here only to demonstrate the variability that exists between the data sets presented in this analysis. How data provided herein are used is determined by the needs of the downstream user, and the assumptions adopted in the developed model. The meteorological properties that are consistently measured at the majority of sites are precipitation and temperature values. Global variability for these parameters is shown in summary plots for average annual precipitation and temperature (Figures 7.1-1 through 7.1-6). Detailed plots of the data are presented in Section 6.

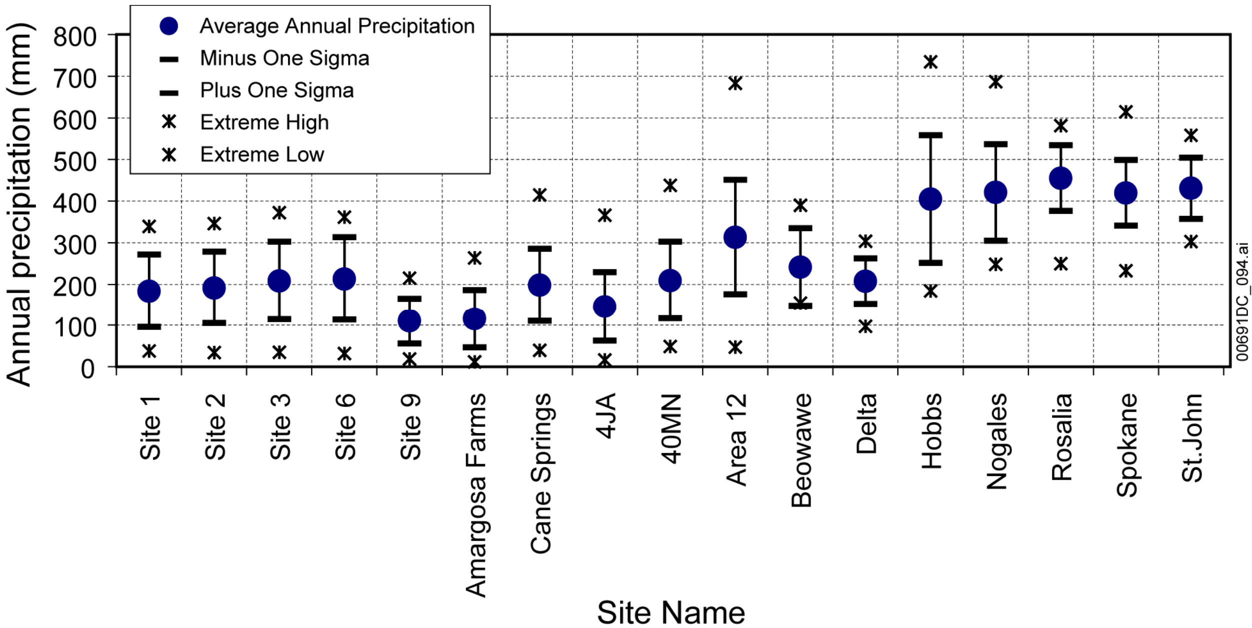
Figure 7.1-1 shows the annual average precipitation, extreme values, and one standard deviation above and below the average for each site. The variability in precipitation for each site is plotted in Figures 7.1-1 and 7.1-2. Descriptive statistics for daily annual precipitation events are listed in Table 7.1-1.

In general, the sites representing present-day climate conditions have lower average annual precipitation than sites representing the monsoon or glacial transition climates. There are a few exceptions, however, and, given the averages, it is possible to have a present-day annual precipitation that is greater than that for a glacial transition climate, a situation seen in the average annual precipitation for the Beowawe and Delta locations.

Both the Beowawe and Delta glacial transition proxy climate locations have lower average annual precipitation than that recorded at the Area 12 location. It is most likely that this is because Area 12 is at the highest elevation of the present-day climate locations (2,243 m amsl), and therefore Area 12 tends to receive more precipitation. Additionally, YM Sites 3 and 6, and 40MN, have a greater average annual precipitation than Delta, a proxy glacial transition location. The proxy climate data have not been adjusted for the elevation at the Yucca Mountain crest. It is expected that mean values and their ranges will differ slightly given the assumptions adopted by the downstream user.

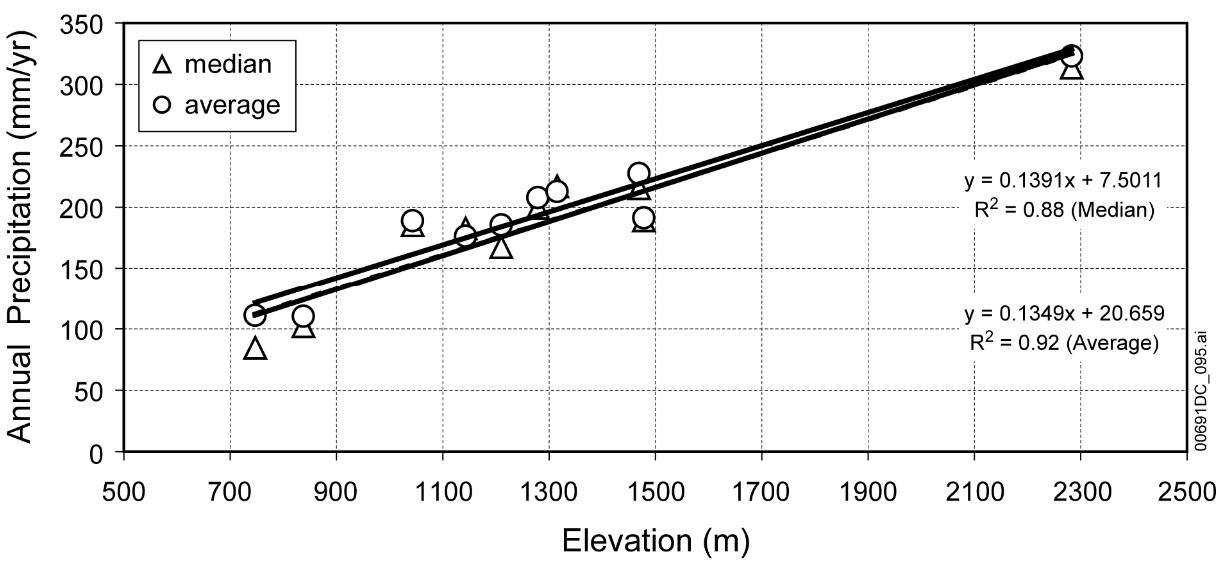
Of the present-day climate sites of YM Sites 1, 2, 3, 6, and 9, Area 12, and 4JA, and MEDA 12 and MEDA 26, located within a 40 km radius of Yucca Mountain, those sites at higher elevations tend to have greater annual precipitation than those at lower elevations. This relationship is illustrated, for informational purposes only, in Figure 7.1-2, in which the median and average annual precipitation are plotted against elevation.

Figure 7.1-2 shows a strong correlation between precipitation and elevation, with the largest average annual precipitation, 323 mm, recorded at Area 12, which is located at the highest elevation, 2,283 m amsl. The smallest annual precipitation, 110.2 mm, is recorded at YM Site 9, which is located at 838 m amsl, the lowest elevation of the present-day sites.



Source: See Appendix F.

Figure 7.1-1. Average, Standard Deviation, and Extreme Values for Average Annual Precipitation



Source: See Appendix F.

NOTE: Meteorological stations representing the present-day climate conditions are YM Sites 1, 2, 3, 6, and 9, and Area 12, 4JA, Amargosa Farms-Garey, 40MN and Cane Springs.

Figure 7.1-2. Average Annual Precipitation versus Elevation at Meteorological Stations Representing Present-day Climate Conditions

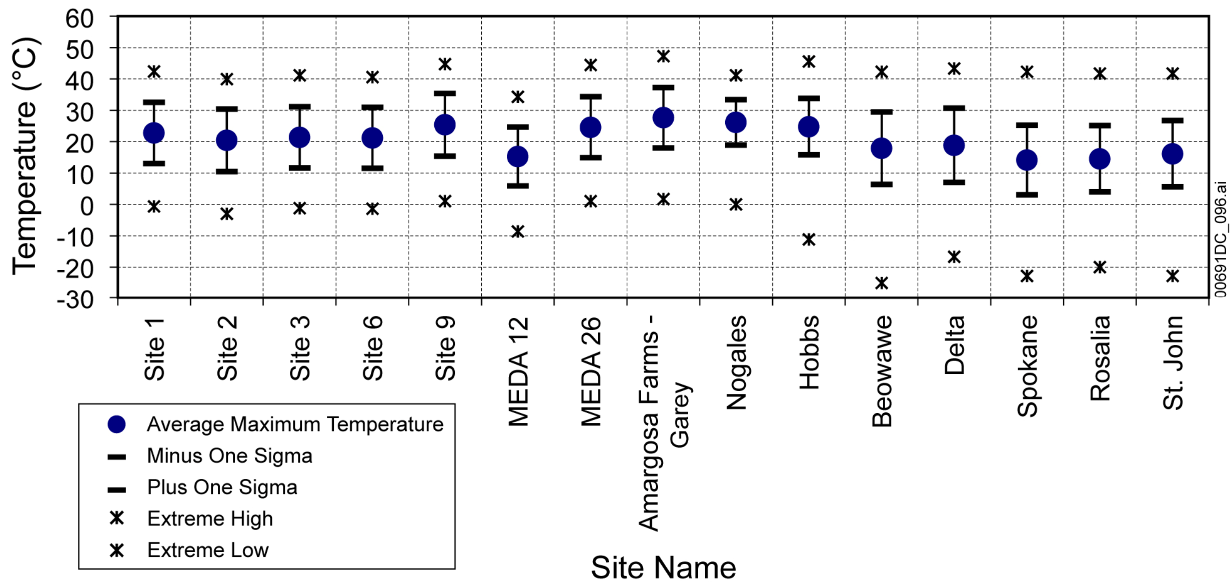
As previously stated, the correlation illustrated in Figure 7.1-2 is for informational purposes only. The correlation between precipitation and elevation in the vicinity of Yucca Mountain that will be developed by the downstream user will depend on their specific assumptions, adopted in their infiltration model.

Table 7.1-1. Average Annual Precipitation, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate

Location	Mean (mm)	Standard Deviation (mm)	Year Range	Number of Years Spanned	Number of Years in This Data Set	Number of Missing Years
Present-Day Sites						
YM Site 1	183.3	88.1	1993–2004	12	12	0
YM Site 2	191.3	86.9	1993–2004	12	12	0
YM Site 3	207.8	94.0	1993–2004	12	12	0
YM Site 6	212.9	99.9	1993–2004	12	12	0
YM Site 9	110.2	54.5	1993–2004	12	12	0
Amargosa Farms–Garey	115.9	69.5	1965–2004	40	27	13
Cane Springs	197.8	87.5	1965–2004	41	40	1
Area 12	312.95	137.59	1959–2004	46	45	1
Site 4JA	145.79	83.31	1959–2004	46	46	0
40MN	209.04	92.82	1961–2004	43	44	0
Future Climate Sites						
Beowawe	241.1	93.3	1983–2001	19	10	9
Delta	207.2	54.6	1972–2003	32	29	3
Hobbs	404.8	153.5	1952–1998	47	37	10
Nogales	420.9	116.00	1948–1982	35	29	6
Rosalia	455.1	78.95	1953–1993	41	28	13
Spokane	419.4	79.0	1948–2003	56	52	4
St. John	430.5	73.4	1964–2001	38	22	16

Average maximum daily temperature recorded at each site is given in Figure 7.1-3, which includes one standard deviation above and below the average temperature, and the highest and lowest maximum temperatures recorded at each site.

Descriptive statistics for daily annual maximum temperatures are listed in Table 7.1-2. With the exception of MEDA 12, the average maximum temperature is the lowest for the glacial transition climates of Beowawe, Delta, Rosalia, Spokane, and St. John (Figure 7.1-3). The maximum mean temperature is highest at the lower elevations of YM Site 9, Amargosa Farms–Garey and and Nogales.



Source: See Appendix F.

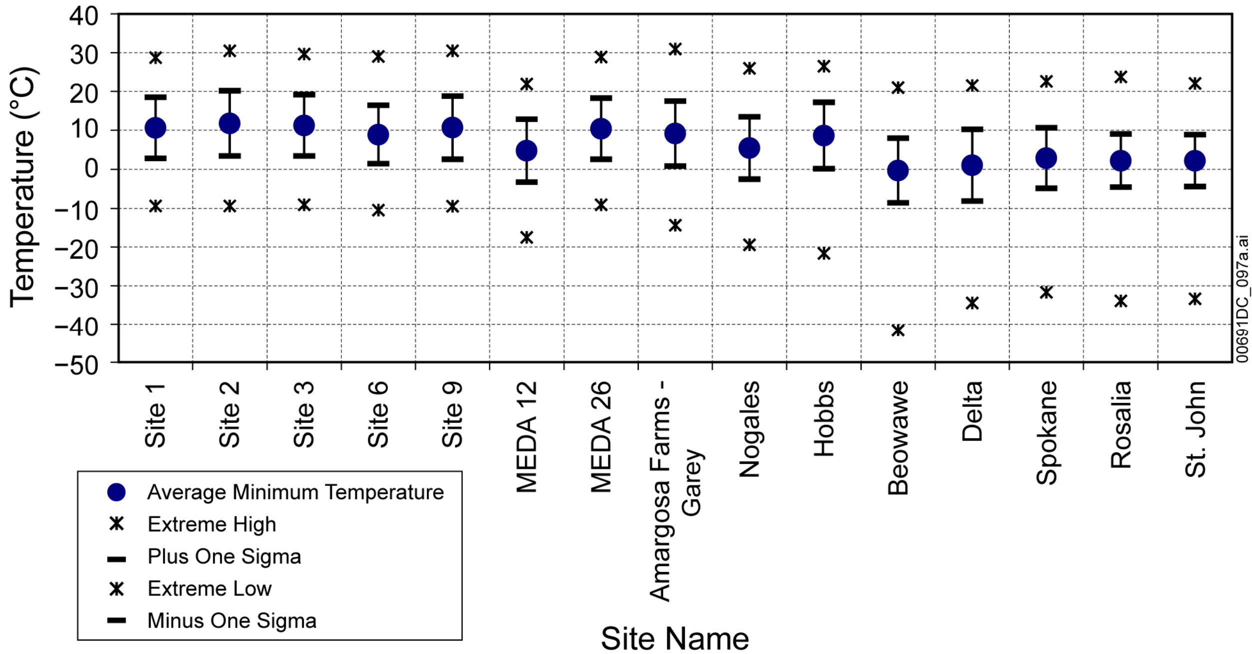
NOTE: See Table 7.1-2 for year/site information.

Figure 7.1-3. Average, Standard Deviation, and Extreme Values for Maximum Daily Temperature

Table 7.1-2. Average Maximum Temperature, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate

Location	Mean (°C)	Standard Deviation (°C)	Year Range	Number of Years Spanned	Number of Years in This Data Set	Number of Missing Years
Present-Day Sites						
YM Site 1	22.7	9.8	1993–2004	12	12	0
YM Site 2	20.4	10.0	1993–2004	12	12	0
YM Site 3	21.3	9.7	1993–2004	12	12	0
YM Site 6	21.2	9.7	1993–2004	12	12	0
YM Site 9	25.4	10.0	1993–2004	12	12	0
Amargosa Farms–Garey	27.6	9.6	1965–2004	40	40	0
MEDA 12	15.2	9.4	1993–2004	12	12	0
MEDA 26	24.6	9.7	1993–2004	12	12	0
Future Climate Sites						
Beowawe	17.9	11.6	1982–2004	23	23	0
Delta	18.8	11.8	1971–2004	34	34	0
Hobbs	24.7	9.0	1947–2001	55	55	0
Nogales	26.1	7.2	1948–1983	36	36	0
Rosalia	14.5	10.6	1949–2004	56	56	0
Spokane	14.1	11.1	1948–2004	57	57	0
St. John	16.1	10.6	1964–2004	41	41	0

The overall average minimum temperature recorded at each site, plus or minus one standard deviation of the average and the extreme minimum temperatures (the highest and lowest minimum temperatures) recorded during the timeframe of the data set, are plotted in Figure 7.1-4. Descriptive statistics for daily annual minimum temperatures are listed in Table 7.1-3. The average minimum temperature is the lowest for the glacial transition climates of Beowawe, Delta, Rosalia, Spokane, and St. John (Figure 7.1-4).



Source: See Appendix F.

Figure 7.1-4. Average, Standard Deviation, and Extreme Values for Minimum Daily Temperature

Table 7.1-3. Average Minimum Temperature, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate

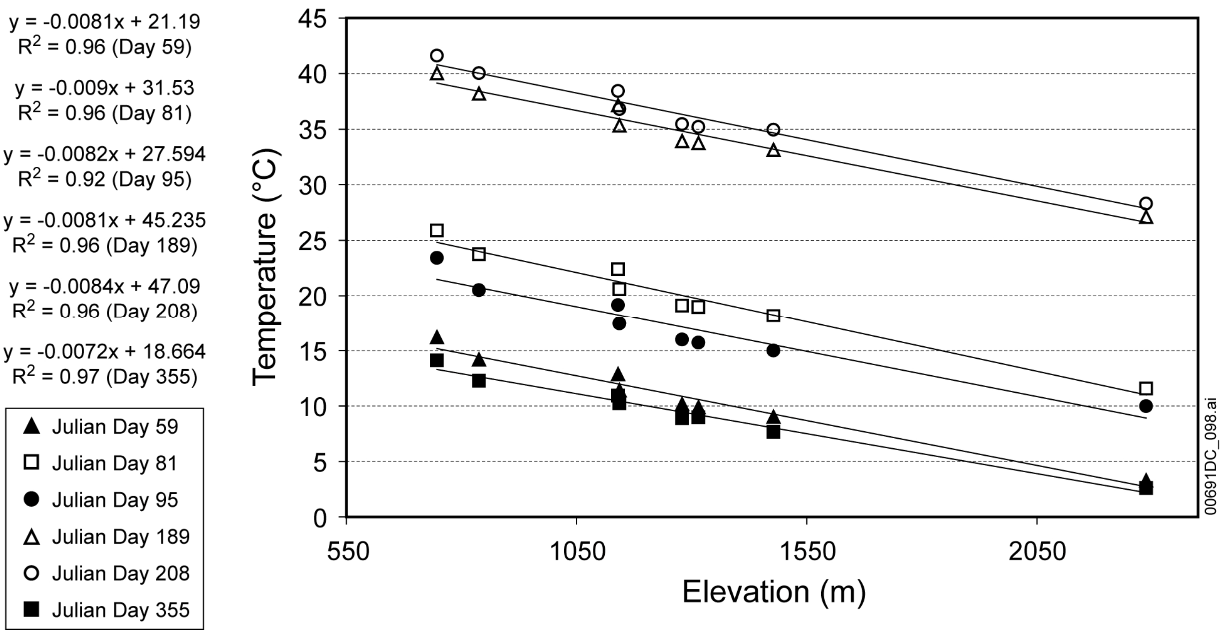
Location	Mean (°C)	Standard Deviation (°C)	Year Range	Number of Years Spanned	Number of Years in This Data Set	Number of Missing Years
Present-Day Sites						
YM Site 1	10.7	7.9	1993–2004	12	12	0
YM Site 2	11.9	8.4	1993–2004	12	12	0
YM Site 3	11.4	8.0	1993–2004	12	12	0
YM Site 6	9.0	7.5	1993–2004	12	12	0
YM Site 9	10.8	8.1	1993–2004	12	12	0
Amargosa Farms–Garey	9.3	8.4	1965–2004	40	40	0
MEDA 12	4.8	8.1	1993–2004	12	12	0
MEDA 26	10.5	7.9	1993–2004	12	12	0

Table 7.1-3. Average Minimum Temperature, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate (Continued)

Location	Mean (°C)	Standard Deviation (°C)	Year Range	Number of Years Spanned	Number of Years in This Data Set	Number of Missing Years
Future Climate Sites						
Beowawe	–0.3	8.3	1982–2004	23	23	0
Delta	1.1	9.2	1971–2004	34	34	0
Hobbs	8.7	8.6	1947–2001	55	55	0
Nogales	5.5	8.0	1948–1983	36	36	0
Rosalia	2.3	6.9	1949–2004	56	56	0
Spokane	2.9	7.8	1948–2004	57	57	0
St. John	2.3	6.7	1964–2004	41	41	0

Surface temperature is strongly affected by topography, inversions, positioning relative to slope, surface radiation, and other factors. Therefore, the correlation between temperature and elevation in developing a temperature "lapse rate" is not as strong as the correlation between elevation and precipitation. The specific lapse rates developed here are only given to illustrate that a lapse rate exists for maximum temperatures, and a weak lapse rate exists for minimum temperatures. The relationship between temperature and elevation, using the average temperature values measured at YM Sites 1, 2, 3, 6, and 9, and at MEDA 12, MEDA 26, and Amargosa Farms–Garey on critical days, is illustrated in Figures 7-5 and 7-6. Critical days (when extreme values occur for the year, and when the daily temperatures transition from one season to another) are recorded throughout the year (Section 6.1.5.3). There is a strong correlation between maximum temperature and elevation on critical days (Figure 7.1-5), which results in lapse rates for maximum temperature that vary between 0.0072°C per meter and 0.009°C per meter. Weak correlations exist between minimum temperature and elevation on critical days, except for Julian day 59 (Figure 7.1-6).

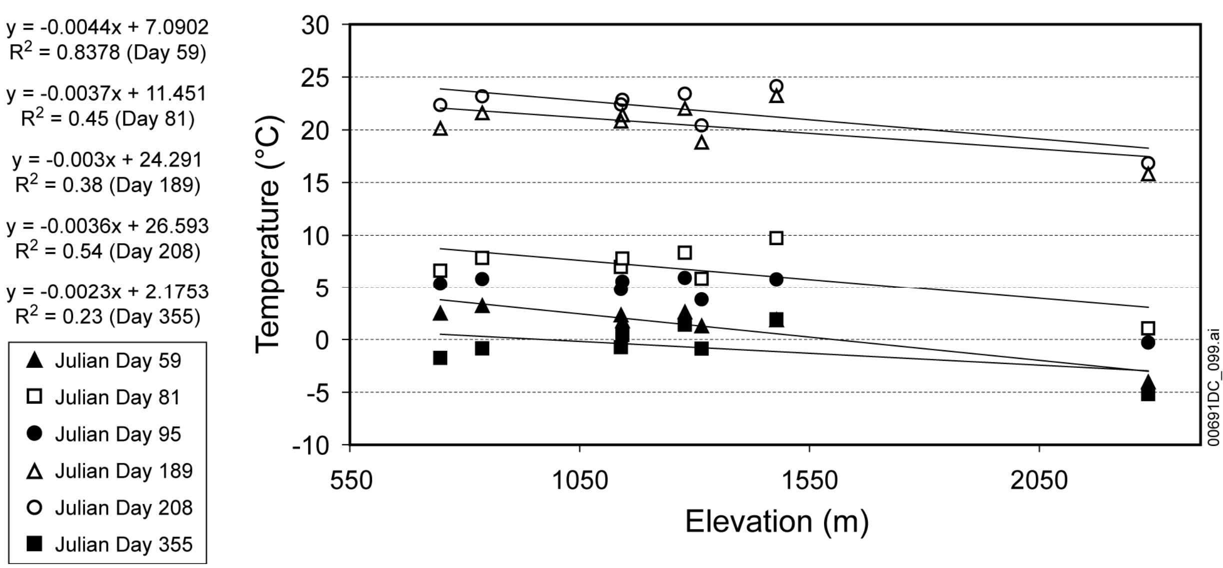
Temperatures for the proxy climate stations are meant to be indicative of temperature variability at the Yucca Mountain crest. Proxy climate temperature values may be adjusted given the temperature lapse rate developed by the downstream user. The lapse rate developed by the downstream user will be dependent on the specific assumptions adopted in the model.



Source: See Appendix F.

NOTE: Sites within a 40 km radius of Yucca Mountain are YM Sites 1, 2, 3, 6, and 9, and MEDA 12, MEDA 26, and Amargosa Farms–Garey.

Figure 7.1-5. Maximum Temperature with Respect to Elevation, Measured on Critical Days at Eight Sites within a 40 km Radius of Yucca Mountain



Source: See Appendix F.

NOTE: Sites within a 40 km radius of Yucca Mountain are YM Sites 1, 2, 3, 6, and 9, and MEDA 12, MEDA 26, and Amargosa Farms–Garey.

Figure 7.1-6. Minimum Temperature with Respect to Elevation, Measured on Critical Days at Eight Sites within a 40 km Radius of Yucca Mountain

7.2 ACCEPTANCE CRITERIA

The analyses of meteorological data in this document help address acceptance criteria given in *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274], Acceptance Criteria 2.1 and 3.1 of Section 2.2.1.3.5.3).

Acceptance criterion 2.1 states:

> Climatological and hydrological values used in the license application (e.g., time of onset of climate change, mean annual temperature, mean annual precipitation, and mean annual net infiltration) are adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.

The data and analyses presented in Section 6 of this document provide the climatological values that will be used in infiltration modeling. The data are described along with an explanation of how the data were interpreted to create the daily climate information required for modeling. The description of the interpretation of the data is adequate to justify the data as the basis for creating parameter values.

Acceptance criterion 3.1 states:

> Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible, reasonably account for uncertainties and variabilities, and do not result in an under-representation of the risk estimate.

The range of variability of the climate parameters is documented in Section 6 of this report by providing data values of the climate variables for the period of record. This will provide the modelers with the range of values necessary to show that uncertainty has been reasonably accounted for in the model predictions.

7.3 DEVELOPED DATA FOR INFILTRATION MODELING

Data intended for use as input for the generation of meteorological conditions in the Yucca Mountain vicinity are provided in output DTNs: SN0608WEATHER1.005, SN0601PRECPTMP.002, SN0603DWEATHER.002, and SN0603TEMPMEDA.002. The representations of present-day and future climates are intended for use in an infiltration model (BSC 2006 [DIRS 177492]). No restrictions have been identified for the intended use of the output DTN data provided herein.

Meteorological stations within a 40 km radius of Yucca Mountain were selected for this analysis based on the completeness of station records and the qualification assurance pedigree. Data extracted from station records were primarily precipitation and temperature data. If available, wind speed, barometric pressure, relative humidity, and dew-point temperature data were also extracted. The results of summary calculations (Section 6) are identified by the output DTNs described in Table 7.3-1.

Table 7.3-1. Developed Meteorological Data

Output File DTN and Title	Description
SN0608WEATHER1.005 Temperature, Precipitation, Wind Speed, Relative Humidity, Dew Point Temperatures, and Barometric Pressure Data Collected from 1993-2004 Measured at Yucca Mountain Weather Stations 1, 2, 3, 6, and 9	Temperature, precipitation, wind speed, relative humidity, dew point temperatures, and barometric pressure data collected from 1993 through 2004, measured at Yucca Mountain weather stations YM Sites 1, 2, 3, 6, and 9. Some of the data in this DTN may be used to represent meteorological information indicative of present-day climate conditions in the Yucca Mountain vicinity.
SN0601PRECPTMP.002 Developed Precipitation Data at NTS Sites from 1959-2004, and Precipitation and Temperature Data at Amargosa Farms–Garey from 1965–2005	Developed precipitation data at NTS sites from 1959 through 2004, and precipitation and temperature data at Amargosa Farms–Garey from 1965 through 2005. Some of the data in this DTN may be used to represent meteorological information indicative of present-day climate conditions in the Yucca Mountain vicinity.
SN0603DWEATHER.002 Developed Weather Station for Beowawe, NV (1982-2004), Delta, UT (1968-2004), Hobbs, NM (1947-2004), Nogales, AZ (1948-1983), Rosalia, WA (1949-2004), St. John, WA (1963-2004), and Spokane, WA (1948-2004)	Developed weather station data for: Beowawe, Nevada, from 1982 through 2004; Delta, Utah, from 1968 through 2004; Hobbs, New Mexico, from 1947 through 2004; Nogales, Arizona, from 1948 through 1983; Rosalia, Washington, from 1949 through 2004; St. John, Washington, from 1963 through 2004; Spokane, Washington, from 1948 through 2004. Some of the data in this DTN may be used to represent meteorological information indicative of the future climate condition in the Yucca Mountain vicinity.
SN0603TEMPMEDA.002 Temperature Data from January 1993 through December 2004 at NTS MEDA Weather Stations 12 and 26	Temperature data from January 1993 through December 2004 at NTS MEDA weather stations MEDA 12 and MEDA 26. Some of the data in this DTN may be used to represent meteorological information indicative of present-day climate conditions in the Yucca Mountain vicinity.
SN0612GEOCOOORD.001 Geographic Coordinates and Elevation for Yucca Mountain Meteorological Sites 1, 2, 3, 6, 8, and 9.	The geographical coordinates (as NAD 27, Zone11) in Nevada State Plane, UTM, and Longitude–Latitude for the YM Meteorological Sites 1, 2, 3, 6, 8, and 9. Elevation (in feet and meters) for YM Meteorological Sites 1, 2, 3, 6, and 9.

DTN = data tracking number; MEDA = meteorological data acquisition; NTS = Nevada Test Site; YM = Yucca Mountain.

8. INPUTS AND REFERENCES

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SCI-PRO-005, Rev. 1, ICN 0. *Scientific Analysis and Calculations.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20061113.0006.

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8.3 SOURCE DATA, LISTED BY DATA TRACKING NUMBER

176098 MO0607SEPMMD04.001. Meteorological Monitoring Data for 2004. Submittal date: 07/18/2006.

176092 MO0312SEPQ1993.001. Meteorological Monitoring Data for 1993. Submittal date: 12/24/2003.

176093 MO0312SEPQ1994.001. Meteorological Monitoring Data for 1994. Submittal date: 12/24/2003.

176094 MO0312SEPQ1995.001. Meteorological Monitoring Data for 1995. Submittal date: 12/24/2003.

176095 MO0312SEPQ1996.001. Meteorological Monitoring Data for 1996. Submittal date: 12/24/2003.

167116 MO0312SEPQ1997.001. Meteorological Monitoring Data for 1997. Submittal date: 12/24/2003.

166731 MO0206SEPQ1998.001. Meteorological Monitoring Data for 1998. Submittal date: 06/26/2002.

166165 MO0302METMON99.001. Meteorological Monitoring Data for 1999, Sites 1-9, Hourly and Ten Minute. Submittal date: 02/13/2003.

166730 MO0209SEPQ2000.001. Meteorological Monitoring Data for 2000. Submittal date: 09/09/2002.

166164 MO0305SEP01MET.002. Meteorological Monitoring Data for 2001. Submittal date: 05/21/2003.

166163 MO0305SEP02MET.002. Meteorological Monitoring Data for 2002. Submittal date: 05/21/2003.

176097 MO0503SEPMMD03.001. Meteorological Monitoring Data For 2003. Submittal date: 03/03/2005.

176099 SN0512NOAADATA.002. NOAA/ARL/SORD NTS Precipitation Data (1959-2004) and Amargosa Farms–Garey Precipitation, and Temperature Data (1965-2005).Submittal date: 12/12/2005.

176100 SN0512NOAADATA.003. NOAA Weather Station Data for Beowawe, NV (1982-2004), Delta, UT (1968-2004), Hobbs, NM (1947-2004), Nogales, AZ (1948-1983), Rosalia, WA (1949-2004), St. John, WA (1963-2004), and Spokane, WA (1948-2004). Submittal date: 12/12/2005.

177242 SN0601SRTMDTED.001. Shuttle Radar Topography Mission (SRTM) Digital Terrain Elevation Data (DTED) of Yucca Mountain, February 2000. Submittal date: 01/23/2006.

176721 SN0603NTSMEDAW.001. 15-Minute Provisional Temperature Data Recorded January 1993 through December 2004 at NTS MEDA Weather Stations 12 and 26. Submittal date: 03/22/2006.

8.4 OUTPUT DATA, LISTED BY DATA TRACKING NUMBER

SN0608WEATHER1.005. Temperature, Precipitation, Wind Speed, Relative Humidity, Dew Point Temperatures, and Barometric Pressure Data Collected from 1993-2004 Measured at Yucca Mountain Weather Stations 1,2,3,6, and 9. Submittal date: 08/23/2006.

SN0603DWEATHER.002. Developed Weather Station Data for Beowawe, NV (1982-2004), Delta, UT (168-2004), Hobbs, NM (1947-2004), Nogales, AZ (1948-1983), Rosalia, WA (1949-2004), St. John, WA (1963-2004), and Spokane, WA (1948-2004). Submittal date: 03/20/2006.

SN0601PRECPTMP.002. Developed Precipitation Data at NTS Sites from 1959-2004, and Precipitation and Temperature Data at Amargosa Farms–Garey from 1965-2005. Submittal date: 1/16/2006.

SN0603TEMPMEDA.002. Temperature Data from January 1993 through December 2004 at NTS MEDA Weather Stations 12 and 26. Submittal date: 03/22/2006.

SN0612GEOCOORD.001. Geographic Coordinates and Elevation for Yucca Mountain Meteorological Sites 1, 2, 3, 6, 8 and 9. Submittal date: 12/11/2006.

8.5 SOFTWARE CODE

155082 CORPSCON V.5.11.08. 2001. WINDOWS NT 4.0. STN: 10547-5.11.08-00.

167994 EARTHVISION V. 5.1. 2000. IRIX 6.5. STN: 10174-5.1-00.

APPENDIX A

QUALIFICATION OF TEMPERATURE DATA FROM MEDA 12 AND MEDA 26

A.1 DATA TO BE QUALIFIED

<u>The Data Set for Qualification</u>

Temperature data from unqualified meteorological stations (DTN: SN0603NTSMEDAW.001) are herein qualified for use in extracting minimum, maximum, and average daily temperature values. The Excel® files used in the qualification process are listed in Appendix B, which includes a compact disc titled *EXCEL Qual Files for Temp at MEDA Stations 12 and 26 Jan93-Dec04* (VER00). The disc contains four compressed folders: *MEDA 12 QualTemps_Sep_06.zip*, *MEDA 26 QualTemps_Sep_06.zip*, *MEDA 12 Preliminary Summary_93_04.zip*, and *MEDA 26 Preliminary Summary_93_04.zip*. These folders contain Excel® files supporting the qualification of temperature data for use in deriving summary temperature data (minimum, maximum, and average daily temperature) for meteorological stations MEDA 12 and MEDA 26, located on the NTS, and the folders include the preliminary files that contain the unqualified temperatures, *MEDA 12 Preliminary Summary_93_04.zip* and *MEDA 26 Preliminary Summary_93_04.zip*.

A.2 RATIONALE FOR SELECTING THE CORROBORATING METHOD TO QUALIFIY DATA

Temperature data from unqualified meteorological stations (DTN: SN0603NTSMEDAW.001) are compared to qualified temperature data measured at the nearby meteorological stations of YM Sites 1 and 2, which are located within the controlled area of Yucca Mountain. With the exception of temperature data recorded at YM Sites 1 and 2 during portions of 1993, temperature sensors at each of the MEDA stations and YM Sites 1 and 2 were operated at 2 m agl. Temperature data at YM Sites 1 and 2 were measured at 10 m agl until May 1, 1993 (Julian day 121), at Site 1, and August 28, 1993 (Julian day 240), at Site 2, after which temperatures were measured at 2 m agl. The 2 m data collection at Site 2 began effective September 1, 1993 (Julian day 244). The temperature differences recorded at YM Sites 1 and 2, due to the 8 m height change of the temperature sensors, do not affect use of the data in corroborating MEDA-station temperature data. The difference in measurement heights is addressed in Assumption 1 in Section 5.

Temperatures measured at MEDA 12, located at 2,287 m amsl, were compared to qualified temperatures recorded for YM Site 2 in output DTN: SN0607WEATHER1.004. Temperatures recorded at YM Site 2 were selected as the corroborating data because the station is located at a relatively high elevation, 1,478 m amsl, and the temperature records from 1993 to 2004 taken at this station have been qualified. Additionally, YM Site 2 is within 43 km of MEDA 12, and shares a similar exposure to the atmosphere because it is located on a crest. Because of elevation differences, a normal temperature gap is expected between the two stations. Thus, MEDA 12, at a higher elevation, will routinely experience lower average temperatures throughout the year than YM Site 2. Elevation-controlled temperature differences notwithstanding, both stations record similar weather fronts, seasonal patterns, and diurnal effects. Thus, similar temperature averages, extremes, and anomalies are recorded.

Temperatures measured at MEDA 26, at 1,140 m amsl, were compared to qualified temperatures recorded for YM Site 1 (output DTN: SN0607WEATHER1.004). YM Site 1 is only 16 km from MEDA 26, and is situated at almost the same elevation, 1,143 m amsl. The temperature at YM Site 1 would be affected by weather fronts and seasonal patterns similar to those that would affect MEDA 26. Thus, temperature averages, extremes, and anomalies at MEDA 26 would be similar to those at YM Site 1.

Temperature data recorded at the MEDA stations are 15-minute values, while the data from YM Sites 1 and 2 are hourly. This time difference will not affect the daily average values, but would have a small effect on the extreme values. However, this difference is small in comparison to the natural differences existing due to the differences in elevation and location.

Given these considerations, use of temperature data recorded at YM Sites 1 and 2 is appropriate for corroborating and qualifying MEDA 12 and MEDA 26 temperature data, respectively.

A.3 EVALUATION CRITERIA

The activities performed herein, as described in Section A.4, provide confidence that, upon qualification, the 15-minute temperature data in SN0603NTSMEDAW.001 are accurate and represent temperature values recorded during the same period for MEDA 12 and MEDA 26. The two criteria used to evaluate the data from stations MEDA 12 and MEDA 26 are that the data are technically correct and reasonably agree with data from YM Sites 2 and 1, respectively, for the same time periods. Specifically, temperature data comparisons between MEDA12-Site 2 and MEDA 26-Site 1 should: (1) follow similar patterns or profiles and, (2) be within 10°C of one another. Upon completion of the qualification process described in the following sections, the 15-minute temperature data for MEDA 12 and MEDA 26 will be shown to be correctly presented and reasonable for their respective locations. Additionally, the 15-minute temperature values and the applicable timeframes recorded for MEDA 12 and MEDA 26 are clearly identified and traceable to their sources.

A.4 AN EVALUTION OF THE TECHNICAL CORRECTNESS OF THE DATA

(1) Screening Out Erroneous and Non-Physical Temperature Values

Two Excel® workbooks were created in the qualification process, one for MEDA 12, titled *MEDA 12 Preliminary Summary_93_04.xls*, and one for MEDA 26, titled *MEDA_26 Preliminary Summary_93_04.xls*.

Within each workbook are 12 worksheets containing the unqualified data, one worksheet for each year of data. Worksheets are named to indicate the year the data were collected; for example, "*M12_93*" indicates 15-minute data collected in 1993 from MEDA 12 and "*M12_04*" indicates 15-minute data collected in 2004 from MEDA 12 (Section 6.4.3).

On these individual calculation worksheets, the data are first screened and processed; the data are then transferred to summary worksheets within each workbook. Using the Excel® AVERAGE function, daily averages were computed on each yearly calculation worksheet from the extracted 15-minute values. Using the Excel® MIN and MAX functions, minimum and maximum daily temperatures, over daily 24-hour periods, were calculated from the extracted 15-minute data.

Diagnostic charts were created to ensure that no unreasonable data were used as inputs to derive minimum or maximum values. These diagnostic charts were generated on yearly worksheets. From these charts, outlier points were determined and removed from the data set, if necessary. In this way, physically unrealistic values, such as temperatures greater than 50°C, were eliminated in the minimum or maximum values. The computed average, minimum, and maximum temperature values were placed in columns to the left of the source data in the worksheet. The computed daily average, minimum, and maximum temperature values were then transferred to summary worksheets.

(2) Qualification Attributes

New qualification workbooks (Appendix B) were created, into which qualified and unqualified temperature data were copied and then graphically plotted and compared (Appendix B). Qualification workbook names are given in Table A-1; details of the workbook contents are given in Appendix B. The resulting processed minimum, maximum, and daily average MEDA temperature data, located on the summary worksheets (Appendix B), were copied from preliminary workbooks into the workbooks listed in Table A-1.

In the qualification workbooks, unqualified summary temperature data have been graphically compared to qualified minimum, maximum, and daily average temperature data measured at nearby stations. Temperature data recorded at MEDA 26 are graphically compared to those recorded at YM Site 1; and temperature data recorded at MEDA 12 are compared to those recorded at YM Site 2. Details of the workbook contents are given in Appendix B.

Table A-1. Qualification Workbooks of MEDA 12 and MEDA 26

MEDA 12 and MEDA 26 Qualification Files
MEDA 12 Qualification Daily Avg T_Sep_06.xls Contains two worksheets with the daily average temperature data from 1993 to 2004 for MEDA 12 and YM Site 2. Contains 12 worksheets with charts (one chart for each year) where averaged daily temperature data from both sites have been plotted together.
MEDA 12 Qualification Daily Min T_Sep_06.xls Contains two worksheets with the daily minimum temperature data from 1993 to 2004 for MEDA 12 and YM Site 2. Contains 12 worksheet with charts (one chart for each year) where minimum daily temperature data from both sites have been plotted together.
MEDA 12 Qualification Daily Max T_Sep_06.xls Contains two worksheets with the daily maximum temperature data from 1993 to 2004 for MEDA 12 and YM Site 2. Contains 12 worksheets with charts (one chart for each year) where maximum daily temperature data from both sites have been plotted together.
MEDA 26 Qualification Daily Average Temp_93 94_Sep_06.xls Contains two worksheets with the daily average temperature data from 1993 to 2004 for MEDA 26 and YM Site 1. Contains 12 worksheets with charts (one chart for each year) where averaged daily temperature data from both sites have been plotted together.

Table A-1. Qualification Workbooks of MEDA 12 and MEDA 26 (Continued)

MEDA 12 and MEDA 26 Qualification Files
MEDA 26 Qualification Daily MinTemp_93 04_Sep_06.xls Contains two worksheets with the daily minimum temperature data from 1993 to 2004 for MEDA 26 and YM Site 1. Contains 12 worksheets with charts (one chart for each year) where minimum daily temperature data from both sites have been plotted together.
MEDA 26 Qualification Daily Max Temp_93 04_Sep_06.xls Contains two worksheets with the daily maximum temperature data from 1993 to 2004 for MEDA 26 and YM Site 1. Contains 12 worksheets with charts (one chart for each year) where maximum daily temperature data from both sites have been plotted together.

NOTE: The files noted in this table are provided on the compact disc titled *EXCEL Qual Files for Temp at MEDA Stations 12 and 26 Jan93-Dec04* (VER00).

MEDA = meteorological data acquisition; YM = Yucca Mountain.

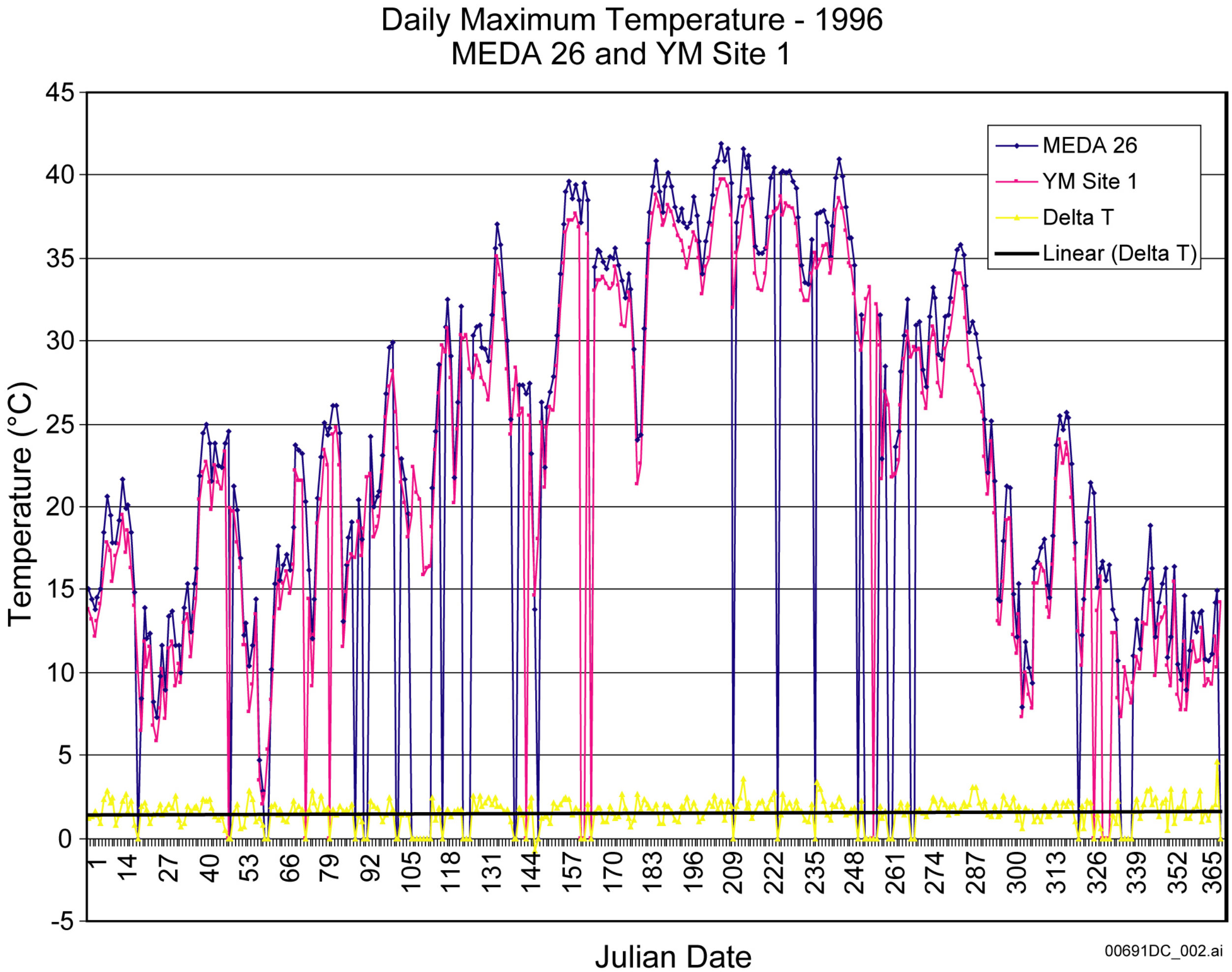
The qualification workbooks contain graphs in which MEDA temperature data are plotted along with temperature data recorded at the YM site stations during the same timeframe. One graph was created for every year of temperature data. These graphs were examined to identify inconsistencies between and anomalies in the two data sets.

It is expected that temperature values and profiles between the MEDA and the Yucca Mountain stations will follow similar diurnal and seasonal fluctuations, with slight variability given their geographical and elevation differences, and be within 10°C of one another. In general, the primary criterion for screening out a MEDA station temperature was whether temperature differences between the qualified and unqualified stations, recorded during the same timeframe, were greater than 10°C. Generally speaking, temperature differences were much less than 10°C. But in instances where local cloud cover occurs impeding incoming or outgoing radiation or when weather fronts are impacted by local topographic variability temperature differences between station locations could be as great as 10°C.

For each temperature element of minimum, maximum, and average daily temperatures, the qualified and unqualified recorded values for the two meteorological stations, along with the temperature differences between the two locations, were plotted on the same graph. If differences between the qualified and unqualified data were greater than 10°C, then the unqualified temperature data for that day were considered suspect and deleted from the data set.

Additionally, if the temperature at a qualified station rose while those at the unqualified station fell or remained constant, then the unqualified recorded values were considered suspect, and further scrutinized by looking at temperature trends recorded between stations. Further investigation of temperature trends recorded at 15-minute or hourly intervals for each station was undertaken, with the intention of determining whether there were anomalies in the data that may have been recorded at these more discrete time intervals. Thus, additional suspicious values of unqualified temperature data were screened out from use in this analysis.

Figure A-1 provides a graphical example of the method used to qualify or screen out suspect temperatures from MEDA data sets. The yellow line on the figure represents typical temperature differences seen between the qualified and unqualified data between the MEDA and the YM site stations for all years. The maximum daily temperature recorded at MEDA 26 and YM Site 1 during 1996 are plotted together, and overlaid with the temperature differences of the daily maximums between the two stations. This plot is the end result of MEDA 26 suspect temperatures already deleted from the data set. Deleted temperatures are indicated by lines that drop to "0" on the plot. Of temperatures that remain in the data set, differences between the two stations are within 10°C, and follow similar diurnal and seasonal fluctuations.



Source: See Appendix F.

Figure A-1. Maximum Daily Temperatures for MEDA 26 and YM Site 1 Recorded in 1996 and Temperature Differences between the Two Stations

A.5 DATA GENERATED BY EVALUATING 15-MINUTE TEMPERATURE VALUES RECORDED AT MEDA 12 AND MEDA 26

The qualified 15-minute temperature data in DTN: SN0603NTSMEDAW.001 were used to develop the daily values of minimum, maximum, and average temperature data summaries in output DTN: SN0603TEMPMEDA.002. The data include daily minimum, maximum, and average temperature values at meteorological stations MEDA 12 and MEDA 26, recorded from January 1993 through December 2004.

A.6 QUALIFICATION CRITERIA TEMPERATURE VALUES RECORDED AT MEDA 12 AND MEDA 26

The 15-minute temperature data in DTN: SN0603NTSMEDAW.001 are qualified for their intended use in deriving minimum, maximum, and average daily temperature data for meteorological stations MEDA 12 and MEDA 26. The data corroboration method using qualified temperature data recorded at nearby meteorological stations fulfills the following qualification criteria:

- The 15-minute temperature data for MEDA 12 and MEDA 26 meet the requirements for accuracy and representation based on comparison with other qualified temperature values recorded during the same timeframe and in the vicinity. Upon qualification, the 15-minute data are used in deriving minimum, maximum, and daily temperature data at the MEDA 12 and MEDA 26 locations during the timeframe that the data were recorded.

- The 15-minute temperature values and the applicable timeframes recorded for MEDA 12 and MEDA 26 are clearly identified and traceable to their sources.

The qualification process documented herein, for the 15-minute temperature data recorded at MEDA 12 and MEDA 26, deems that the temperature values are correctly presented and reasonable. This determination is based on MEDA 12 and MEDA 26 temperature values meeting the evaluation criteria (as presented in Section A.3), in comparison with the corroborative qualified sources, Site 2 and Site 1, respectively.

A.7 CONCLUSION

Unqualified temperature data in DTN: SN0603NTSMEDAW.001 are qualified for use in this analysis only. The data qualification performed under the guidance described herein and the data qualification plan (a facsimile of which is attached below) are appropriate for use in deriving minimum, maximum, and daily temperature data at MEDA 12 and 26, located on the NTS.

A.8 RATIONALE FOR NOT USING OTHER QUALIFICATION METHODS DESCRIBED IN LP-SIII 2.Q, ATTACHMENT 4

The following explains why this analysis uses the corroboration method to qualify data, and why it does not use other methods in the qualification process.

Attachment 4 in the procedure for qualifying unqualified data, LP-SIII.2Q-BSC, contains the five methods available for the qualification process. Methods 1, 2, and 3 also require an initial evaluation of the data quality and correctness, which was performed during the qualification process. Method 2 is the Corroborating Data method, which was used for the qualification process. The remaining methods, and rationale for not using them, follow.

Method 1, Equivalent QA Program, could apply if the data acquisition and processing could be demonstrated to be functionally equivalent to the general process requirements that were applicable to the Yucca Mountain meteorological monitoring program. The information and documentation on the SORD monitoring program was not readily available for this process, so this method was not pursued.

Method 3, Confirmatory Testing, is not applicable to the irretrievable meteorological conditions occurring during the monitoring period.

Method 4, Peer Review, is an intensive process that could be needed if none of the previous three methods was appropriate. Since the corroboration method is acceptable to qualify the MEDA data, the Peer Review method was not pursued.

Method 5, Technical Assessment, is another intensive process that could be used if an independent evaluation of the data were needed to raise the confidence in the data. Since the corroboration approach provided satisfactory results, this method was not pursued.

A.9 DATA LIMITATIONS

The unqualified data in DTN: SN0603NTSMEDAW.001 have been qualified in this analysis solely for purposes of developing minimum, maximum, and average daily temperature values at the selected locations. These developed temperature summaries are identified by the output DTN: SN0603TEMPMEDA.002.

BSC	**Data Qualification Plan** *Complete only applicable items.*	QA: QA Page 1 of 1

Section I. Organizational Information

Qualification Title

Qualification Of Temperature Data Taken from meteorological stations MEDA 12 and MEDA 26

Requesting Organization

Infiltration Technical Team

Section II. Process Planning Requirements

1. List of Unqualified Data to be Evaluated

SN0603NTSMEDAW.001 *15-Minute Provisional Temperature Data Recorded January 1993 through December 2004 at NTS MEDA Weather Stations 12 and 26.* Note: This data will be used to derive minimum, maximum, and average daily temperature data for MEDA 12 and MEDA 26 during the same period of record.

2. Type of Data Qualification Method(s) [Including rationale for selection of method(s) (Attachment 3) and qualification attributes (Attachment 4)]

A Corroborating Method of the Data Temperature data from the unqualified meteorological stations, DTN: SN0603NTSMEDAW.001 *15-Minute Provisional Temperature Data Recorded January 1993 through December 2004 at NTS MEDA Weather Stations 12 and 26*, are compared with qualified temperature data from nearby stations. It is expected that temperatures measured at meteorological data acquisition (MEDA) stations, MEDA 12 and MEDA 26, will follow similar diurnal and seasonal fluctuations and be within a few degrees of temperatures measured at nearby meteorological stations. Temperatures from MEDA 12 and MEDA 26 are qualified using the corroboration method. The corroborating data are qualified ambient temperature data recorded at nearby Yucca Mountain (YM) meteorological stations. The corroborating data were collected using operational and maintenance procedures, instrument calibration, and data review processes implemented during the same timeframe, in compliance with *Quality Assurance and Requirements Description* (DOE 2004 [DIRS 171539]).

3. Data Qualification Team and Additional Support Staff Required

Kathleen Economy - Qualification Chairperson
Dale Ambos – Technical Staff

4. Data Evaluation Criteria

Qualification Attributes will graphically demonstrate Item 3 of Attachment 5 in LP-SIII.2Q-BSC. That the data demonstrate the minimum, maximum, and average daily temperature values for MEDA Stations 12 and 26 located at the Nevada Test Site. Specific criteria to be used to corroborate temperature data between the unqualified data station and the corroborating station are, the temperature data from both stations should: 1) follow similar patterns or profiles over the same period of time and, 2) be within 10°C of one another.

5. Identification of Procedures Used

LP-SIII.2Q-BSC

LP-SIII.2Q-BSC FORM NO. LSIII2-1 (Rev. 01/19/2005)

BSC	Data Qualification Plan *Complete only applicable items.*	QA: QA Page 2 of 1

Section III. Approval		
Qualification Chairperson Printed Name Kathleen Economy	Qualification Chairperson Signature Kathleen Economy	Date Sept 26, 2006
Responsible Manager Printed Name Gerald Nieder-Westermann	Responsible Manager Signature [signature]	Date 09/26/2006

LP-SIII.2Q-BSC FORM NO. LSIII2-1 (Rev. 01/19/2005)

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APPENDIX B

ELECTRONIC QUALIFICATION FILES OF MEDA 12 AND MEDA 26 TEMPERATURE DATA RECORDED BETWEEN JANUARY 1993 AND DECEMBER 2004

Appendix B includes a compact disc titled *EXCEL Qual Files for Temp at MEDA Stations 12 and 26 Jan93-Dec04* (VER00). The disc contains four compressed folders: *MEDA 12 Preliminary Summary_93_04.zip, MEDA_26 Preliminary Summary_93_04.zip*, *MEDA 12 QualTemps_Sep06.zip*, and *MEDA 26 QualTemps_Sep06.zip.* These folders contain eight Excel® workbooks with associated worksheets described in Table B-1 and Table B-2. The data and plots in these workbooks contain unqualified and the qualified corroborating temperature data used to produce the qualified daily temperature data for MEDA 12 and MEDA 26, given in output DTN: SN0603TEMPMEDA.002.

Table B-1. Qualification Files of MEDA 12 Temperatures Recorded between January 1993 and December 2004

MEDA 12 Qualification Files
MEDA 12 Preliminary Summary_93_04.xls. (Packed size, 5,594 KB; dated 5/4/2006 2:40 PM) (a) Three summary worksheets: Daily Min Temp, Daily Max Temp, Daily Avg Temp. These worksheets contain the screened and processed summary temperatures derived from the 15-minute temperature reading located on the yearly calculation worksheets. The results from the summary worksheet are copied to the "qualification" workbooks, where they are corroborated against summary data from YM Site 2. (b) Twelve worksheets: M12_93, M12_94, M12_95, M12_96, M12_97, M12_98, M12_99, M12_00, M12_01, M12_02, M12_03, M12_04. These worksheets contain 15-minute temperature data; there is one worksheet for every year. It is on these worksheets that the 15-minute temperature data are screened for physically unrealistic values, and are used to calculate daily values of minimum, maximum, and average temperature. The results are transferred to summary worksheets.
MEDA12 *Qualification Daily Avg T_Sep27_06.xls*. (Packed size, 359,243 KB; dated 9/27/2006 2:40 PM) This workbook contains the following worksheets: MEDA 12 – Worksheet contents: Average Daily Temperatures in °C, recorded for MEDA 12 from January 1993 through December 2004 SITE 2 – Worksheet contents: Average Daily Temperatures in °C, recorded for YM Site 2 from January 1993 through December 2004 COMPARE – Average daily temperature differences between MEDA 12 and YM Site 2 Yearly Worksheets – Twelve yearly worksheets with plots of average daily temperatures over the specified year for the unqualified temperature data (MEDA 12) and the qualified temperature data (YM Site 2) overlaid with average temperature differences between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.
MEDA 12 *Qualification Daily Min T_Sep27_06.xls*. (Packed size, 280,390 KB; dated 9/27/2006 2:44 PM) This workbook contains the following worksheets: MEDA 12 – Worksheet contents: Minimum Daily Temperatures in °C, recorded for MEDA 12 from January 1993 through December 2004 SITE 2 – Worksheet contents: Minimum Daily Temperatures in °C, recorded for YM Site 2 from January 1993 through December 2004 COMPARE – Minimum daily temperatures differences between MEDA 12 and YM Site 2 Yearly Worksheets – Twelve worksheets with plots of minimum daily temperatures over the specified year for the unqualified temperature data (MEDA 12) and the qualified temperature data (YM Site 2) overlaid with temperature differences of the minimums between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.

Table B-1. Qualification Files of MEDA 12 Temperatures Recorded between January 1993 and December 2004 (Continued)

MEDA 12 Qualification Files (Continued)
MEDA 12 *Qualification Daily Max T_Sep27_06.xls*. (Packed size, 302, 877 KB; dated 9/27/2006 2:43 PM) This workbook contains the following worksheets: MEDA 12 – Worksheet contents: Maximum Daily Temperatures in °C, recorded for MEDA 12 from January 1993 through December 2004 SITE 2 – Worksheet contents: Maximum Daily Temperatures in °C, recorded for YM Site 2 from January 1993 through December 2004 COMPARE – Maximum daily temperatures differences between MEDA 12 and YM Site 2 Yearly Worksheets – Twelve worksheets with plots of maximum daily temperatures over the specified year for the unqualified temperature data (MEDA 12) and the qualified temperature data (YM Site 2) overlaid with temperature differences of the maximums between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.

MEDA = meteorological data acquisition; YM = Yucca Mountain

Table B-2. Qualification Files of MEDA 26 Temperatures Recorded between January 1993 and December 2004

MEDA 26 Qualification Files
MEDA_26 Preliminary Summary_93_04.xls.xls (Packed size, 6,842 KB; dated 3/23/06 3:07PM), (a) Three summary worksheets: Daily Min Temp, Daily Max Temp, Daily Avg Temp. These worksheets contain the processed summary temperatures that are derived from the 15-minute temperature reading located on the yearly calculation worksheets. (b) Twelve worksheets: M26_93, M26_94, M26_95, M26_96, M26_97, M26_98, M26_99, M26_00, M26_01, M26_02, M26_03, M26_04. These worksheets contain 15-minute temperature data; there is one worksheet for every year. It is on these worksheets that the 15-minute temperature data are screened for unrealistic values, and are used to calculate daily values of minimum, maximum, and average temperatures. The results are transferred to the summary worksheets.
MEDA 26 Qualification Files
MEDA 26 *Qualification Daily Average Temp_93-04_Sep27_06.xls*. (Packed size, 399,231 KB; dated 9/27/2006 2:04 PM) This workbook contains the following worksheets: MEDA 26 – Worksheet contents: Average Daily Temperatures in °C, recorded for MEDA 26 from January 1993 through December 2004 SITE 1 – Worksheet contents: Average Daily Temperatures in °C, recorded for YM Site 1 from January 1993 through December 2004 COMPARE – Average daily temperatures differences between MEDA 26 and YM Site 1 Yearly Worksheets – Twelve worksheets with plots of average daily temperatures over the specified year for the unqualified temperature data (MEDA 26) and the qualified temperature data (YM Site 1) overlaid with average temperature differences between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.

Table B-2. Qualification Files of MEDA 26 Temperatures Recorded between January 1993 and December 2004 (Continued)

MEDA 26 Qualification Files (Continued)
MEDA 26 *Qualification Daily MinTemp_ 93-04_Sep27_06.xls*. (Packed size, 274,590 KB; dated 9/27/2006 1:53 PM) This workbook contains the following worksheets: MEDA 26 – Worksheet contents: Minimum Daily Temperatures in °C, recorded for MEDA 26 from January 1993 through December 2004 SITE 1 – Worksheet contents: Minimum Daily Temperatures in °C, recorded for YM Site 1 from January 1993 through December 2004 COMPARE – Minimum daily temperatures differences between MEDA 26 and YM Site 1 Yearly Worksheets – Twelve worksheets with plots of minimum daily temperatures over the specified year for the unqualified temperature data (MEDA 26) and the qualified temperature data (YM Site 1) overlaid with temperature differences, of the minimums, between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.
MEDA 26 *Qualification Daily Max Temp_93-04_ Sep27_06.xls*. (Packed size, 265,495 KB; dated 9/27/2006 3:42 PM) This workbook contains the following worksheets: MEDA 26 – Worksheet contents: Maximum Daily Temperatures in °C recorded for MEDA 26 from January 1993 through December 2004 SITE 1 – Worksheet contents: Maximum Daily Temperatures in °C recorded for YM Site 1 from January 1993 through December 2004 COMPARE – Maximum daily temperatures differences between MEDA 26 and YM Site 1 Yearly Worksheets – Twelve worksheets with plots of maximum daily temperatures over the specified year for the unqualified temperature data (MEDA 26) and the qualified temperature data (YM Site 1) overlaid with temperature differences, of the maximums, between the two stations. Worksheets are labeled: 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, and 2004.

MEDA = meteorological data acquisition; YM = Yucca Mountain

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APPENDIX C

COPY OF MATHCAD® FILES

C.1 FUTURE CLIMATE DATA

Problem Statement:

The text below contains functions that are used to process daily weather data from the proxy climate weather stations. The purpose of each function is described before the function is defined.

By setting the system variable ORIGIN equal to one, all array indices are set to 1 instead of the default value of 0.

ORIGIN := 1

This function is used to extract a particular type of daily weather data, identified by the string variable, *datastring*, from a data file read into the matrix, M. The data files to be used with this routine are in DTN: SN0512NOAADATA.003. For example, to extract daily values of minimum temperature, *datastring* should be set to equal "TMIN."

This function works with weather station data from all proxy climate sites except Spokane. The data file from the Spokane station includes an additional column of data that is not present in the files for the other stations. To extract data from the Spokane station file, the function read_climate_data2() must be used.

```
read_climate_data1(M, datastring) := | "Determine the row indicies for the requested data string"
                                     | j ← 1
                                     | for  i ∈ 1 .. rows(M)
                                     |    | rowpar_j ← i  if  M_{i,5} = datastring
                                     |    | yearmonth_j ← M_{i,7}
                                     |    | j ← j + 1  if  M_{i,5} = datastring
                                     | "Compile matrix of requested values from each day column"
                                     | j ← 1
                                     | for  k ∈ 9, 13 .. 129
                                     |    | for  r ∈ 1 .. rows(rowpar)
                                     |    |    | A_{r,j} ← M_{(rowpar_r), k}
                                     |    |    | B_{r,j} ← yearmonth_r
                                     |    | j ← j + 1
                                     | C ← | C1 ← (A^T)^<1>
                                     |     | for  i ∈ 2 .. cols(A^T)
                                     |     |   C1 ← stack[C1, (A^T)^<i>]
                                     |     | C1
                                     | YM ← | D1 ← (B^T)^<1>
                                     |      | for  i ∈ 2 .. cols(B^T)
                                     |      |   D1 ← stack[D1, (B^T)^<i>]
                                     |      | D1
                                     | for  i ∈ 1 .. rows(YM)
                                     |    | YM_i ← num2str(YM_i)
                                     |    | Year_i ← substr(YM_i, 0, 4)
                                     |    | Year_i ← str2num(Year_i)
                                     |    | Month_i ← substr(YM_i, 4, 2)
                                     |    | Month_i ← str2num(Month_i)
                                     |    | Day_i ← mod(i, 31)  if  mod(i, 31) ≠ 0
                                     |    | Day_i ← 31  otherwise
                                     | augment(Year, Month, Day, C)
```

This function is used to extract weather data from the Spokane station. Refer to the preceding description for more information.

```
read_climate_data2 (M , datastring ) := | "Determine the row indicies for the requested data string"
                                        | j ← 1
                                        | for  i ∈ 1 .. rows (M )
                                        |     | rowpar_j ← i  if  M_{i,6} = datastring
                                        |     | yearmonth_j ← M_{i,8}
                                        |     | j ← j + 1  if  M_{i,6} = datastring
                                        | "Compile matrix of requested values from each day column"
                                        | j ← 1
                                        | for  k ∈ 10 , 14 .. 130
                                        |     | for  r ∈ 1 .. rows (rowpar )
                                        |     |     | A_{r,j} ← M_{(rowpar_r),k}
                                        |     |     | B_{r,j} ← yearmonth_r
                                        |     | j ← j + 1
                                        | C ← | C1 ← (A^T)^⟨1⟩
                                        |     | for  i ∈ 2 .. cols (A^T)
                                        |     |     C1 ← stack [C1 , (A^T)^⟨i⟩]
                                        |     | C1
                                        | YM ← | D1 ← (B^T)^⟨1⟩
                                        |      | for  i ∈ 2 .. cols (B^T)
                                        |      |     D1 ← stack [D1 , (B^T)^⟨i⟩]
                                        |      | D1
                                        | for  i ∈ 1 .. rows (YM )
                                        |     | YM_i ← num2str (YM_i)
                                        |     | Year_i ← substr (YM_i , 0 , 4)
                                        |     | Year_i ← str2num (Year_i)
                                        |     | Month_i ← substr (YM_i , 4 , 2)
                                        |     | Month_i ← str2num (Month_i)
                                        |     | Day_i ← mod (i , 31 )  if  mod (i , 31 ) ≠ 0
                                        |     | Day_i ← 31  otherwise
                                        | augment (Year , Month , Day , C )
```

The following function accepts a matrix M of data records, created by read_climate_data1() or read_climate_data2(), and filters out data marked by the error flags "–9999" and "9999."

```
Filter(M) := | j ← 1
             | for  i ∈ 1 .. rows(M)
             |    | for  k ∈ 1 .. cols(M)
             |    |    F_{j,k} ← M_{i,k}  if  M_{i,4} ≠ −99999 ∧ M_{i,4} ≠ 99999
             |    | j ← j + 1  if  M_{i,4} ≠ −99999 ∧ M_{i,4} ≠ 99999
             | F
```

The following function arranges daily precipitation values into columns of complete years (March 1 through February 28 of next year). Row 1 lists the year (for March 1 start day), row 2 lists precipitation on the day preceding March 1 (February 28th or 29th), and rows 3 through 367 list the precipitation amounts, in mm, for each day from March 1 to February 28.

```
CompleteYearPrecip(PRCP) := | yrcount ← 0
                            | for i ∈ 1 .. rows(PRCP)
                            |   | yrcount ← yrcount + 1 if PRCP[i,3] = 3 ∧ PRCP[i,4] = 1
                            |   | index[yrcount] ← i if PRCP[i,3] = 3 ∧ PRCP[i,4] = 1
                            | for j ∈ 1 .. rows(index) − 1
                            |   | flag[j] ← 0
                            |   | for c ∈ index[j] .. index[j+1] − 1
                            |   |   flag[j] ← −1 if PRCP[c+1,1] − PRCP[c,1] ≠ 1
                            |   | continue if flag[j] = −1
                            |   | ppt1[1,j] ← PRCP[(index[j]),2]
                            |   | ppt1[2,j] ← PRCP[(index[j])−1,5] if PRCP[(index[j])−1,4] ≥ 28
                            |   | ppt1[2,j] ← "n/a" otherwise
                            |   | nextindex ← index[j+1] − 1 if PRCP[(index[j+1])−1,4] = 28
                            |   | nextindex ← index[j+1] − 2 if PRCP[(index[j+1])−1,4] = 29
                            |   | for i ∈ index[j] .. nextindex
                            |   |   | k ← i − index[j] + 3
                            |   |   | ppt1[k,j] ← PRCP[i,5]
                            | j ← 1
                            | for c ∈ 1 .. cols(ppt1)
                            |   | ppt2<j> ← ppt1<c> if ppt1[1,c] ≠ 0
                            |   | j ← j + 1 if ppt1[1,c] ≠ 0
                            | ppt2
```

C.2 MONSOON CLIMATE DATA

Problem Statement:

Functions presented in this section extract daily values of minimum and maximum temperatures and precipitation from files obtained from weather stations at the two locations identified as proxy climate locations for the monsoon climate for the Yucca Mountain Project. In addition, the precipitation data are organized into a format required as input for the stochastic modeling of precipitation.

Sources of Input:

Data files for each station were downloaded from the Internet, and are included in the following DTNs:

- SN0512NOAADATA.003, *64086727775dat.txt* (Hobbs, NM)
- SN0512NOAADATA.003, *721532727755dat.txt* (Nogales, AZ).

Steps Used to Reformat the Data With Mathcad®:

The data were reformatted using a Mathcad® calculation, by first opening the Mathcad® file listed below and running the calculation to the end of the sheet. This operation took approximately 2 minutes on a 3.2-GHz Pentium 4 with 2 GB of RAM. Once the calculation was completed, the Excel® data components were saved as external files.

Read in Routines Used to Extract and Filter Data:

The user must provide a directory structure as to where the actual Mathcad® series of functions are located. The example below gives a directory structure referenced to run the Mathcad® program.

Reference:

C:\Parent_Dirctory\Subdiretory1\ Subdiretory2 \ *Future-climate-routines_3-9-2006.xmcd*(R)

Process Data from Hobbs, NM:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003/64086727775dat.txt" ,"delimited")
PRCP := read_climate_data1(DAT,"PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT,"TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT,"TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4\rangle} := \left(TMIN^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

$$TMAX^{\langle 4\rangle} := \left(TMAX^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4\rangle} := PRCP^{\langle 4\rangle}\cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *"Hobbs_TMIN_TMAX_PPT.xls"* (output file listed in Table 6.3-3)

$$\begin{pmatrix} DTMINhob \\ DTMAXhob \\ DPRCPhob \end{pmatrix} :=$$

Hobbs, NM						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
				[deg C]		
17168	1947	1	1	-7.22222	17168	1947
17169	1947	1	2	-6.11111	17169	1947
17170	1947	1	3	-16.6667	17170	1947
17171	1947	1	4	-19.4444	17171	1947
17172	1947	1	5	-15.5556	17172	1947
17173	1947	1	6	-6.11111	17173	1947
17174	1947	1	7	-3.33333	17174	1947

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINhob := augment(DTMINhob , TMIN)
TMAXhob := augment(DTMAXhob , TMAX)
PRCPhob := augment(DPRCPhob , PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28). The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *"Hobbs_Precipitation.xls"* (output file listed in Table 6.3-4)

Hobbs, NM	Note: Years listed in row 2 below denote years from March 1 of the yeai					
Year	***1952***	***1954***	***1955***	***1957***	***1959***	***1960***
day preceeding	0	0	0	0	0	0
1-Mar	0	0	0	0	0	0
2-Mar	0	0	0	0	0	0
3-Mar	0	0	0	0	0	0
4-Mar	0	0	0	0	0	0
5-Mar	0	0	0	0	0	0
6-Mar	0	0	0	0	0	0
7-Mar	0	0	0	0	0	0
8-Mar	0	0	0	0	0	0
9-Mar	0	0	0	0	0	0

```
CompleteYearPrecip(PRCPhob)
```

Process Data from Nogales, AZ:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003/721532727755dat.txt" ,"delimited")
PRCP := read_climate_data1(DAT,"PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT,"TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT,"TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4 \rangle} := \left(TMIN^{\langle 4 \rangle} - 32\right) \cdot \frac{5}{9}$$

$$TMAX^{\langle 4 \rangle} := \left(TMAX^{\langle 4 \rangle} - 32\right) \cdot \frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4 \rangle} := PRCP^{\langle 4 \rangle} \cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Nogales_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

$$\begin{pmatrix} DTMINnog \\ DTMAXnog \\ DPRCPnog \end{pmatrix} :=$$

Nogales, AZ						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
				[deg C]		
17533	1948	1	1	-10	17533	1948
17534	1948	1	2	-9.44444	17534	1948
17535	1948	1	3	-6.66667	17535	1948
17536	1948	1	4	-4.44444	17536	1948
17537	1948	1	5	-3.88889	17537	1948
17538	1948	1	6	-2.22222	17538	1948
17539	1948	1	7	-2.77778	17539	1948

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

$$TMINnog := augment(DTMINnog, TMIN)$$
$$TMAXnog := augment(DTMAXnog, TMAX)$$
$$PRCPnog := augment(DPRCPnog, PRCP)$$

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Nogales_Precipitation.xls* (output file listed in Table 6.3-4)

Nogales, AZ	Note: Years listed in row 2 below denote years from March 1 of the yeai					
Year	***1948***	***1951***	***1953***	***1954***	***1955***	***1956***
day preceeding	2.286	1.27	26.67	0	0	0
1-Mar	2.032	0	0	0	0	0
2-Mar	0	1.016	12.7	0	0	0
3-Mar	0	0	12.192	0	0	0
4-Mar	0	0	0	4.572	0	0
5-Mar	0	0	0	0	0	0
6-Mar	0	0	0	0	0	0
7-Mar	0	0	0	0	0	0
8-Mar	0	0.508	0.254	0	0	0
9-Mar	0	0.762	0	0	0	0

CompleteYearPrecip(PRCPnog)

C.3 GLACIAL TRANSITION CLIMATE DATA

Problem Statement:

The following functions are used to extract daily values of minimum and maximum temperatures and precipitation from files obtained from weather stations at the two locations identified as proxy climate locations for the glacial transition climate for the Yucca Mountain Project. In addition, the precipitation data are organized into a format required as input for the stochastic modeling of precipitation.

Sources of Input:

Data files for each station were downloaded from the Internet, and are included in the following DTNs:

- SN0512NOAADATA.003, *896109725272dat.txt* (Beowawe, NV)
- SN0512NOAADATA.003, *833900726569dat.txt* (Delta, UT)
- SN0512NOAADATA.003, *195364725137dat.txt* (Rosalia, WA)
- SN0512NOAADATA.003, *906143725006dat.txt* (Spokane, WA)
- SN0512NOAADATA.003, *978568725270dat.txt* (St. John, WA).

Steps Used to Reformat the Data With Mathcad®:

The data were reformatted using a Mathcad® calculation, by first opening the Mathcad® file listed below and running the calculation to the end of the sheet. This operation took approximately 2 minutes on a 3.2-GHz Pentium 4 with 2 GB of RAM. Once the calculation was completed, the Excel® data components were saved as external files.

Read in Functions Used to Extract and Filter Data:

The user must provide a directory structure as to where the actual Mathcad® series of functions are located. The example below gives a directory structure referenced to run the Mathcad® program.

Reference:

C:\Parent_Dirctory\Subdiretory1\ Subdiretory2 \ *Future-Climate-Routines_3-9-2006.xmd*(R)

Process Data from Beowawe, NV:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX).

```
DAT := READFILE("SN0512NOAADATA_003\896109725272dat.txt" ,"delimited")
PRCP := read_climate_data1(DAT,"PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT,"TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT,"TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4\rangle} := \left(TMIN^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

$$TMAX^{\langle 4\rangle} := \left(TMAX^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4\rangle} := PRCP^{\langle 4\rangle}\cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Beowawe_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

(DTMIN DTMAX DPRCP) :=

Beowawe, NV						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
29952	1982	1	1	-5	29952	1982
29953	1982	1	2	-7.22222	29953	1982
29954	1982	1	3	-11.1111	29954	1982
29955	1982	1	4	-2.77778	29955	1982
29956	1982	1	5	-4.44444	29956	1982
29957	1982	1	6	-23.3333	29957	1982
29958	1982	1	7	-26.6667	29958	1982

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINbeo := augment(DTMIN, TMIN)
TMAXbeo := augment(DTMAX, TMAX)
PRCPbeo := augment(DPRCP, PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Beowawe_Precipitation.xls* (output file listed in Table 6.3-4)

Beowawe, NV	Note: Years listed in row 2 below denote years from March 1 of the yeaı					
Year	*1983*	*1986*	*1987*	*1988*	*1989*	*1993*
day preceeding	1.524	0	0	0.254	0	0
1-Mar	0	0	0	6.35	0	0
2-Mar	0	0.762	0	4.318	3.048	0
3-Mar	0	4.064	0	0	1.778	2.794
4-Mar	4.318	0	0	0	0	0.762
5-Mar	0	0	0	0.254	0	0
6-Mar	0	0	1.524	0	8.382	0
7-Mar	3.81	0	2.286	0	0.254	0
8-Mar	1.27	0	1.524	0	1.524	0
9-Mar	0	0	3.048	0	1.778	0

CompleteYearPrecip(PRCPbeo)

Process Data from Delta, UT

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003\833900726569dat.txt" ,"delimited")
PRCP := read_climate_data1(DAT,"PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT,"TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT,"TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4\rangle} := \left(TMIN^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

$$TMAX^{\langle 4\rangle} := \left(TMAX^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4\rangle} := PRCP^{\langle 4\rangle}\cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Delta_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

$$\begin{pmatrix} DTMIN \\ DTMAX \\ DPRCP \end{pmatrix} :=$$

Delta, UT						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
24929	1968	4	1	7.222222	24929	1968
24930	1968	4	2	3.333333	24930	1968
24931	1968	4	3	2.777778	24931	1968
24932	1968	4	4	-1.66667	24932	1968
24933	1968	4	5	2.222222	24933	1968
24934	1968	4	6	0	24934	1968
24935	1968	4	7	-1.66667	24935	1968

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINdel := augment(DTMIN, TMIN)
TMAXdel := augment(DTMAX, TMAX)
PRCPdel := augment(DPRCP, PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Delta_Precipitation.xls* (output file listed in Table 6.3-4)

Delta, UT	Note: Years listed in row 2 below denote years from March 1				
Year	***1972***	***1973***	***1975***	***1976***	***1978***
day preceeding	0	0	0	0	0
1-Mar	0	0	0	5.588	1.016
2-Mar	0	0	0	1.778	5.842
3-Mar	0	0	0	2.286	4.318
4-Mar	0	0.254	0	0	2.794
5-Mar	0	0.762	2.286	0	2.794
6-Mar	0	0	0	0	0.762

CompleteYearPrecip(PRCPdel)

Process Data from Rosalia, WA:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003\195364725137dat.txt" , "delimited")
PRCP := read_climate_data1(DAT , "PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT , "TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT , "TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4 \rangle} := \left(TMIN^{\langle 4 \rangle} - 32\right) \cdot \frac{5}{9}$$

$$TMAX^{\langle 4 \rangle} := \left(TMAX^{\langle 4 \rangle} - 32\right) \cdot \frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4 \rangle} := PRCP^{\langle 4 \rangle} \cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Rosalia_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

(DTMIN DTMAX DPRCP) :=

Rosalia, WA						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
17921	1949	1	23	-16.6667	17922	1949
17922	1949	1	24	-24.4444	17923	1949
17923	1949	1	25	-29.4444	17924	1949
17924	1949	1	26	-27.7778	17925	1949
17925	1949	1	27	-14.4444	17926	1949
17926	1949	1	28	-24.4444	17927	1949
17927	1949	1	29	-22.2222	17928	1949

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINros := augment(DTMIN , TMIN)
TMAXros := augment(DTMAX , TMAX)
PRCPros := augment(DPRCP , PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Rosalia_Precipitation.xls* (output file listed in Table 6.3-4)

Rosalia, WA	Note: Years listed in row 2 below denote years from March 1 of the year					
Year	***1953***	***1956***	***1958***	***1959***	***1960***	***1963***
day preceeding	2.032	2.54	0	0	0	0
1-Mar	0	0	0	0	0	0
2-Mar	0	0	0	0	0	0
3-Mar	0	0	0	0	0	0.254
4-Mar	0	2.54	0	0	3.048	0
5-Mar	0	0.508	0	0	4.318	0.254
6-Mar	0	0	2.54	0	0	0
7-Mar	0	0	0	1.27	4.064	0
8-Mar	0	2.286	2.794	0	6.604	0
9-Mar	0	0	0	0	1.27	0

CompleteYearPrecip(PRCPros)

Process Data from Spokane, WA:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003\906143725006dat.txt" , "delimited")
PRCP := read_climate_data2(DAT , "PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data2(DAT , "TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data2(DAT , "TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4\rangle} := \left(TMIN^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

$$TMAX^{\langle 4\rangle} := \left(TMAX^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4\rangle} := PRCP^{\langle 4\rangle}\cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function DATE(). Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Spokane_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

$\begin{pmatrix} DTMIN \\ DTMAX \\ DPRCP \end{pmatrix}$:=

Spokane, WA						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
				[deg C]		
17533	1948	1	1	-1.66667	17533	1948
17534	1948	1	2	0	17534	1948
17535	1948	1	3	-2.22222	17535	1948
17536	1948	1	4	-1.11111	17536	1948
17537	1948	1	5	-5	17537	1948
17538	1948	1	6	0	17538	1948
17539	1948	1	7	-0.55556	17539	1948

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINspo := augment(DTMIN , TMIN)
TMAXspo := augment(DTMAX , TMAX)
PRCPspo := augment(DPRCP , PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *Spokane_Precipitation.xls* (output file listed in Table 6.3-4)

Spokane, WA	Note: Years listed in row 2 below denote years from March 1 of the yeai				
Year	***1948***	***1949***	***1950***	***1951***	***1952***	***1954***
day preceeding	0	0	0	0	2.794	0
1-Mar	1.27	0	0	0	0	0
2-Mar	0	0	3.048	0.254	0	0
3-Mar	0	0	1.524	4.318	1.27	0
4-Mar	0	0	7.62	1.016	2.286	0
5-Mar	0	0	16.764	1.524	0.508	0
6-Mar	0	0	0	4.826	0	0
7-Mar	0	0	0	1.778	0	0
8-Mar	0	3.302	3.048	7.112	0	5.08
9-Mar	0	0	5.842	0.762	7.874	13.97

CompleteYearPrecip(PRCPspo)

Process Data from St. John, WA:

Read in raw data file, and extract daily values of precipitation (PRCP) and minimum and maximum temperatures (TMIN and TMAX):

```
DAT := READFILE("SN0512NOAADATA_003\978568725270dat.txt" , "delimited")
PRCP := read_climate_data1(DAT , "PRCP")
PRCP := Filter(PRCP)
TMIN := read_climate_data1(DAT , "TMIN")
TMIN := Filter(TMIN)
TMAX := read_climate_data1(DAT , "TMAX")
TMAX := Filter(TMAX)
```

Change units of original temperature data from degrees F to degrees C:

$$TMIN^{\langle 4\rangle} := \left(TMIN^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

$$TMAX^{\langle 4\rangle} := \left(TMAX^{\langle 4\rangle} - 32\right)\cdot\frac{5}{9}$$

Convert precipitation from hundredths of an inch to millimeters:

$$PRCP^{\langle 4\rangle} := PRCP^{\langle 4\rangle}\cdot 0.254$$

Save daily values of TMIN, TMAX, and PRCP to an Excel® worksheet. Use Excel® to calculate an integer date, using the function "DATE()". Shift the integer date so that it is equal to 1 on January 1 of the first year of data. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *StJohn_TMIN_TMAX_PPT.xls* (output file listed in Table 6.3-3)

(DTMIN DTMAX DPRCP) :=

St John, WA						
DIGDATE	Year	Month	Day	TMIN	DIGDATE	Year
23255	1963	9	1	13.33333	23255	1963
23256	1963	9	2	12.22222	23256	1963
23257	1963	9	3	4.444444	23257	1963
23258	1963	9	4	10.55556	23258	1963
23259	1963	9	5	7.777778	23259	1963
23260	1963	9	6	7.222222	23260	1963
23261	1963	9	7	7.222222	23261	1963

(TMIN TMAX PRCP)

Add the shifted integer date to data matrices:

TMINstj := augment(DTMIN, TMIN)
TMAXstj := augment(DTMAX, TMAX)
PRCPstj := augment(DPRCP, PRCP)

Output precipitation data to an Excel® file listing only complete years (March 1 – Feb 28) for use with the stochastic precipitation model. The steps are:

1. Double-click on the Excel® component to the left
2. Click out of the area
3. Right-click on the component, and select "Save As"
4. Name the file: *StJohn_Precipitation.xls* (output file listed in Table 6.3-4)

St John, WA	Note: Years listed in row 2 below denote years from March 1 of the year					
Year	***1964***	***1965***	***1966***	***1967***	***1968***	***1969***
day preceeding	0	0	1.524	0	0	0
1-Mar	0	0	0.508	0	0	0
2-Mar	6.35	0	0	2.54	0	0
3-Mar	0	0	0	0.508	0	0
4-Mar	5.08	0	0	0	0	0
5-Mar	5.842	0	1.778	0	0	11.938
6-Mar	0	0	0	0	0	0
7-Mar	0	0	16.764	0	0	0
8-Mar	2.286	0	7.366	0	0	0
9-Mar	2.54	0	15.748	0	0	0

CompleteYearPrecip(PRCPstj)

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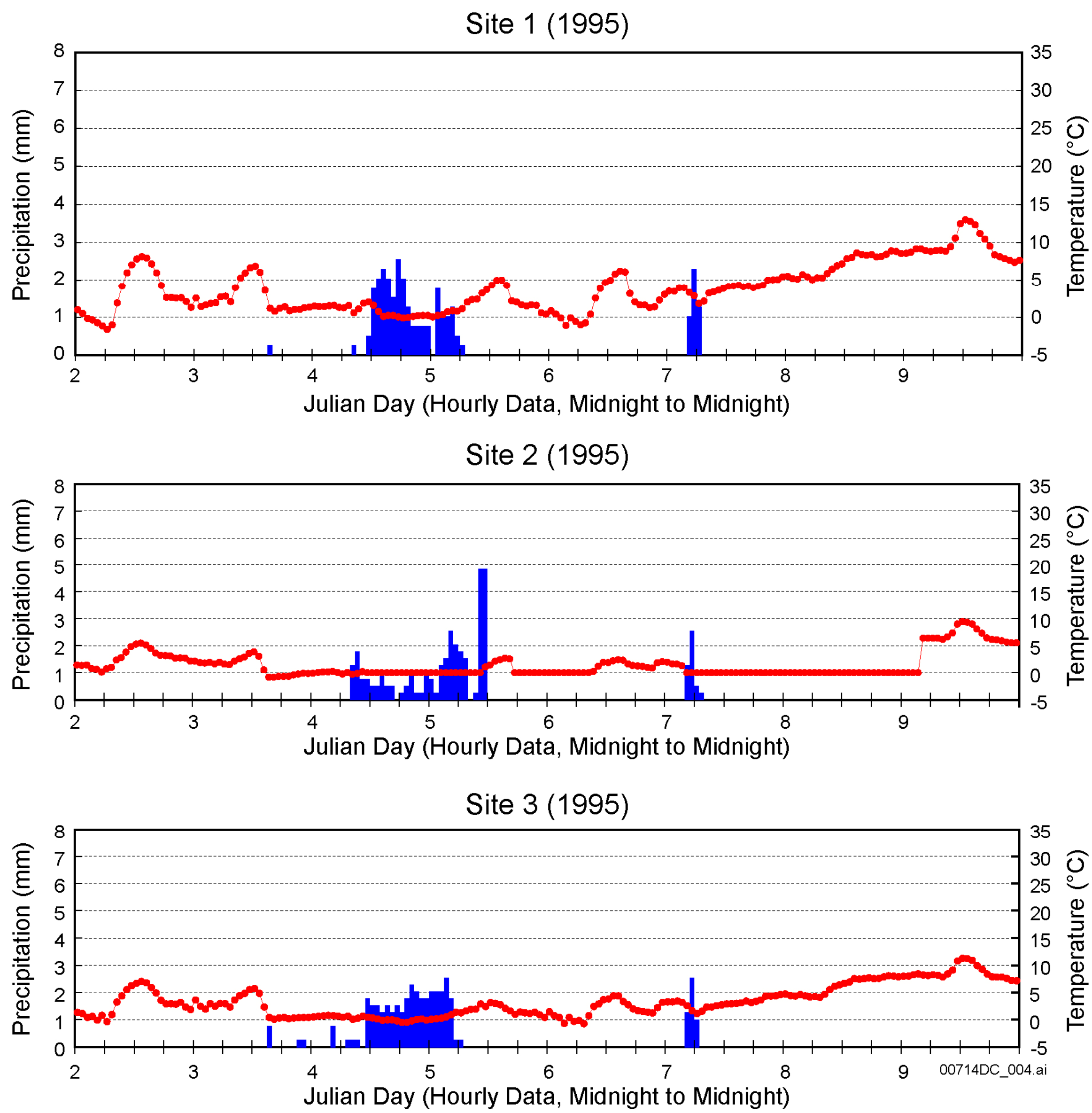
APPENDIX D

PRECIPITATION AND TEMPERATURE PLOTTED FROM SELECTED DATASETS FOR YEARS 1995, 1998, AND 2002

Displaying data in combination charts, consisting of a line-column figure on two axes, is a valuable visual tool used here to help identify patterns or trends between hourly precipitation and temperature data. The figures included in Appendix D can assist the analyst to discover any correlation between hourly precipitation and temperature data recorded at the seven locations discussed in this analysis, those being YM Sites 1, 2, 3, 6, and 9, and sites 4JA-MEDA 26 and Area 12-MEDA 12. These locations are within a 40 km radius of Yucca Mountain.

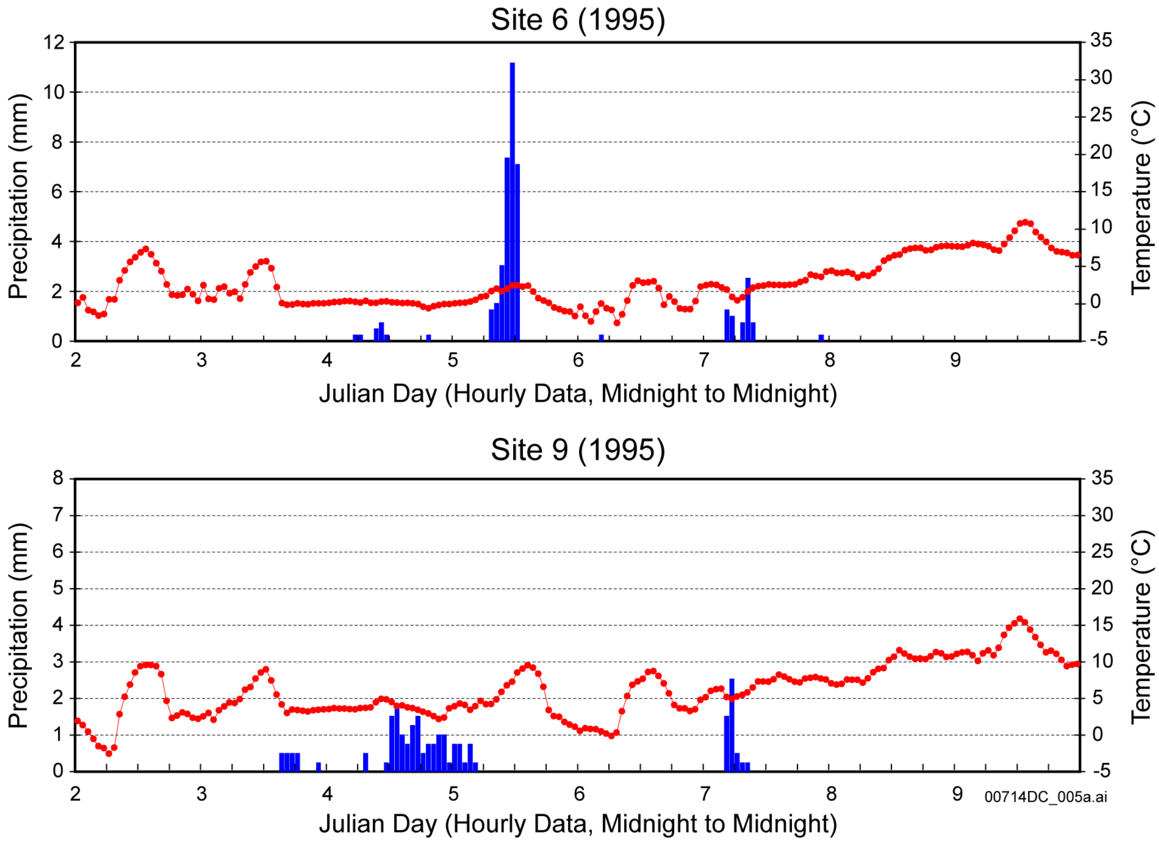
Precipitation-temperature charts are presented here for data collected at YM Sites 1, 2, 3, 6, and 9. In addition, precipitation data recorded at site 4JA is plotted with temperature data from MEDA 26, and Area 12 precipitation data are plotted with MEDA 12 temperature data. The precipitation-temperature data used in this analysis were recorded between 1993 and 2004. Within this period, data were selected from three years: 1998, the wettest year; 2002, the driest year; and 1995, a moderately wet year. These three contrasting years were chosen to capture any real-time interrelationship between these two climatic elements of precipitation and temperature. Comparing precipitation and temperature data between sites and over the same period provides insights into the spatial and temporal diversities and similarities between sites, relative to precipitation and temperature.



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

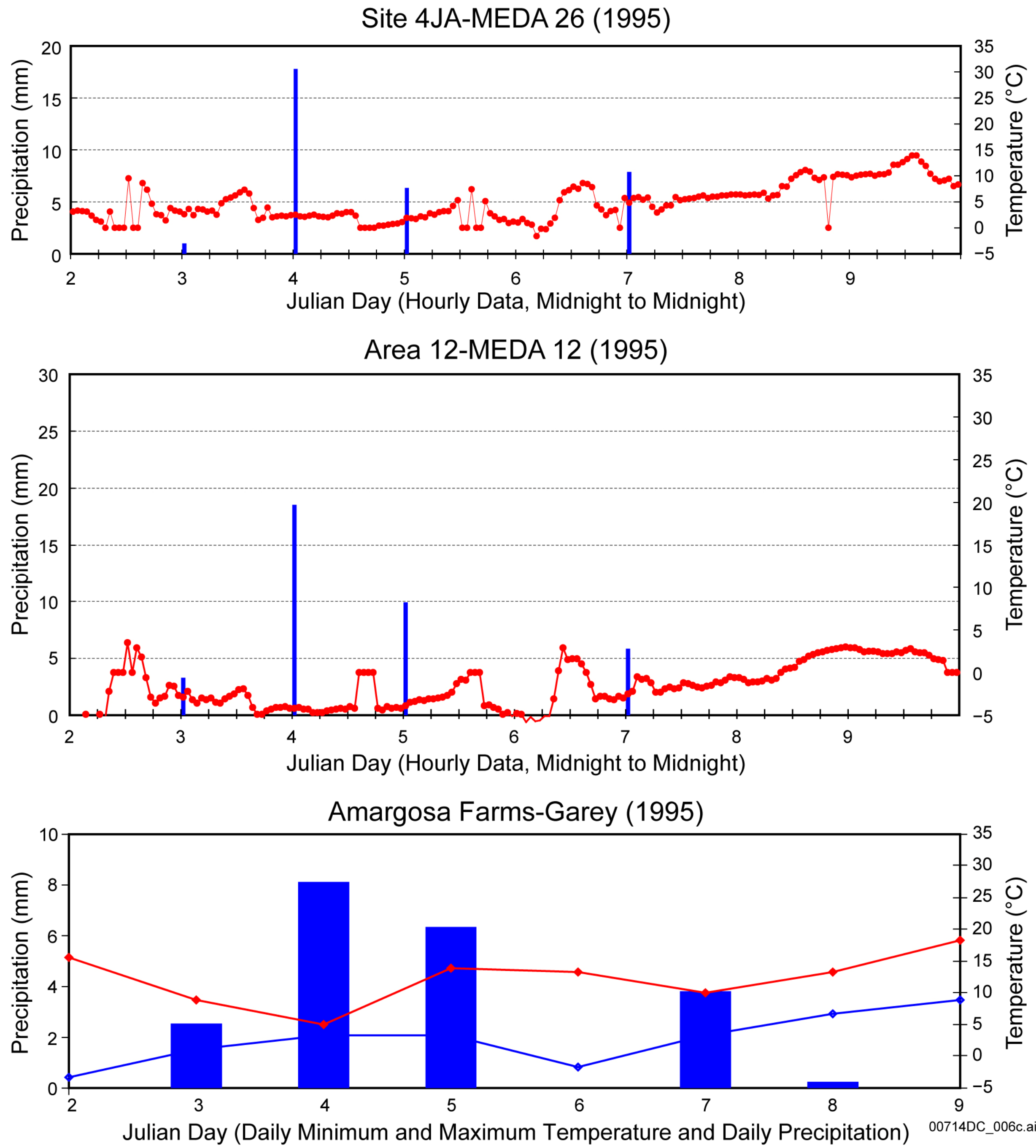
Figure D-1a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 2 through 9 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

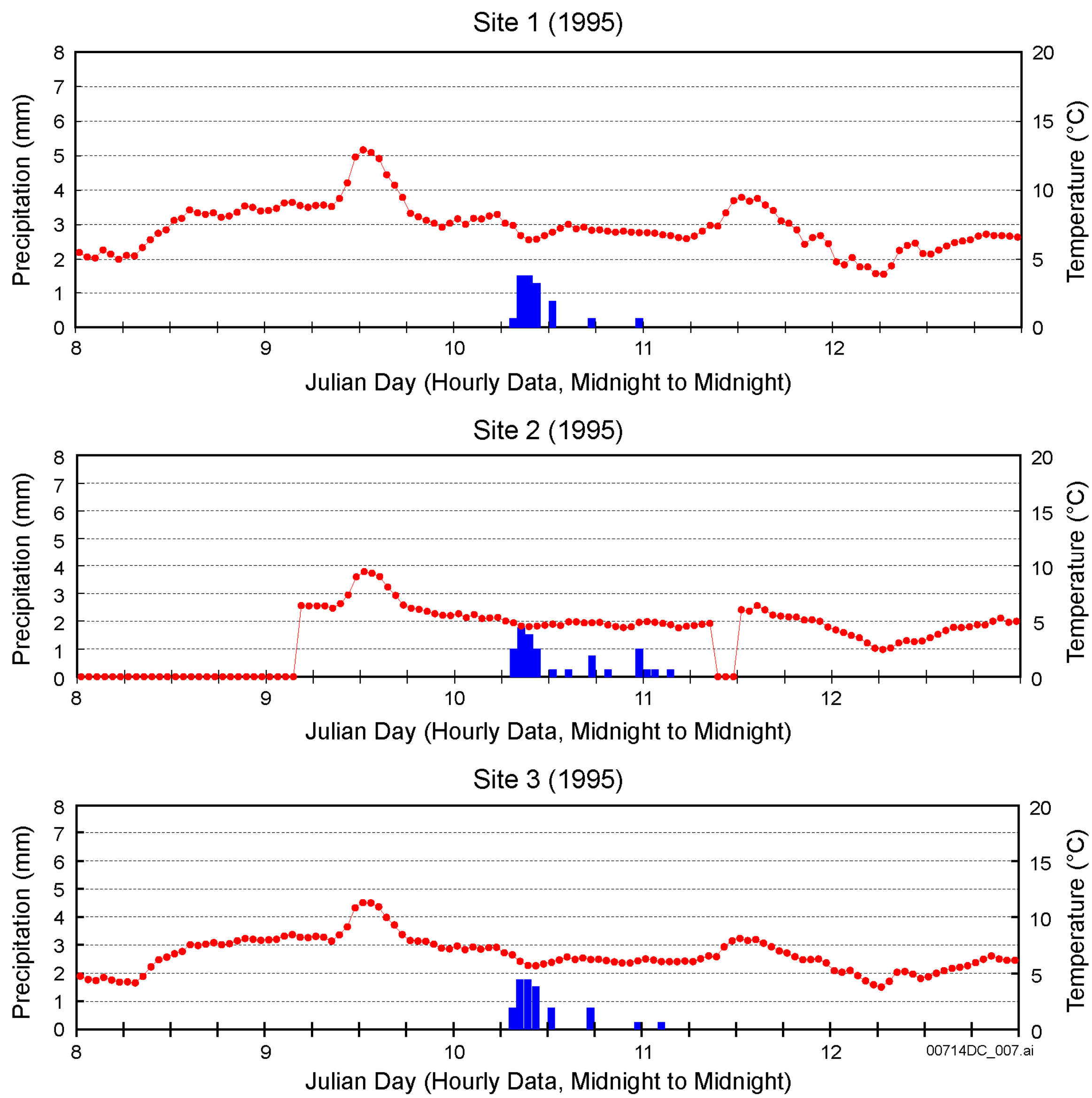
Figure D-1b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 2 through 9 in 1995



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

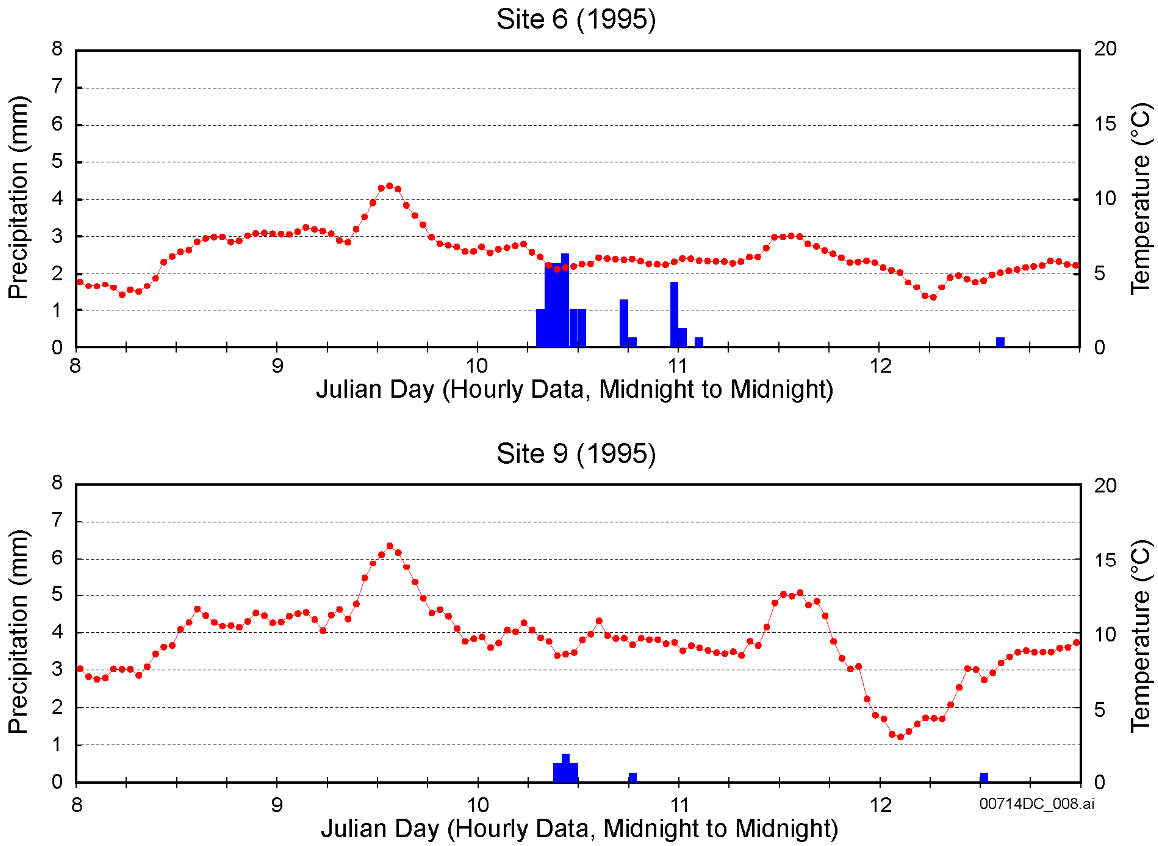
Figure D-1c. Temperature and Precipitation for Site 4JA–MEDA 26, Area12–MEDA 12, and Amargosa Farms–Garey for Julian Days 2 through 9 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. A temperature reading of zero in the graph is a result of the recording "N/A" for that specific hour (YM Site 2). Plots may vary in format and range.

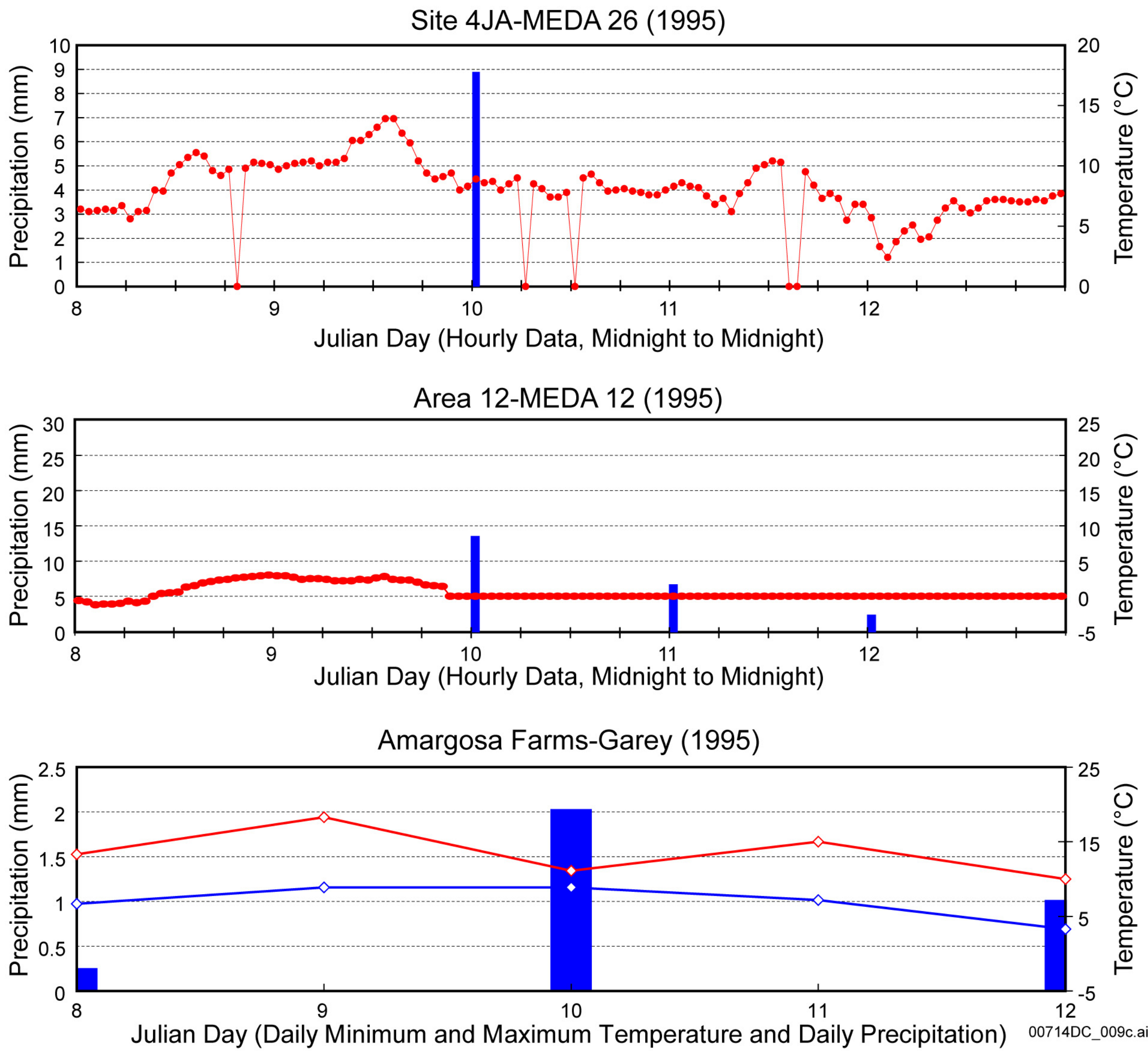
Figure D-2a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 8 through 12 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

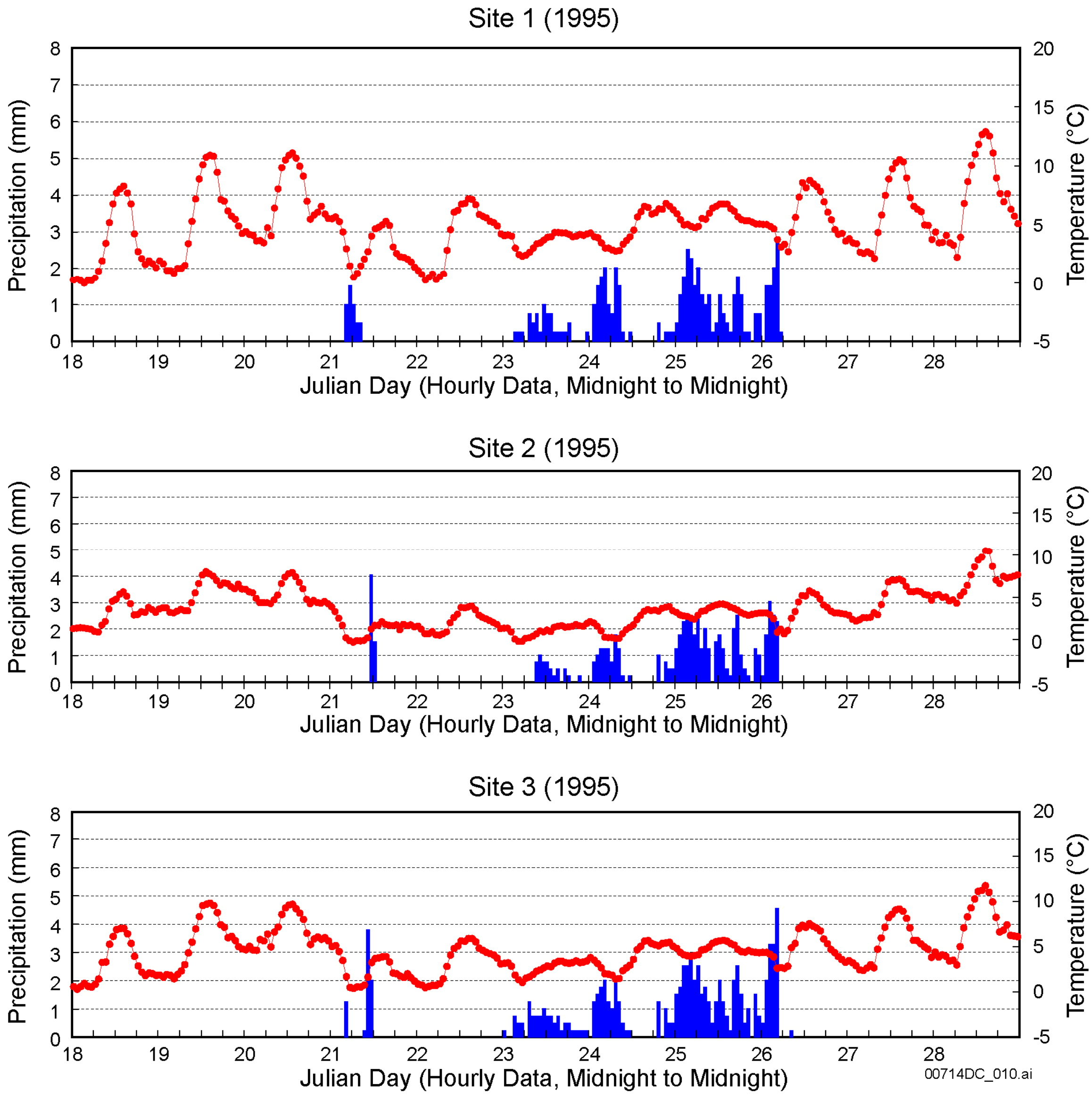
Figure D-2b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 8 through 12 in 1995



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
A temperature reading of zero in the graph is a result of the recording “N/A” for that specific day (missing data).
No precipitation was recorded for Area 12–MEDA 12.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

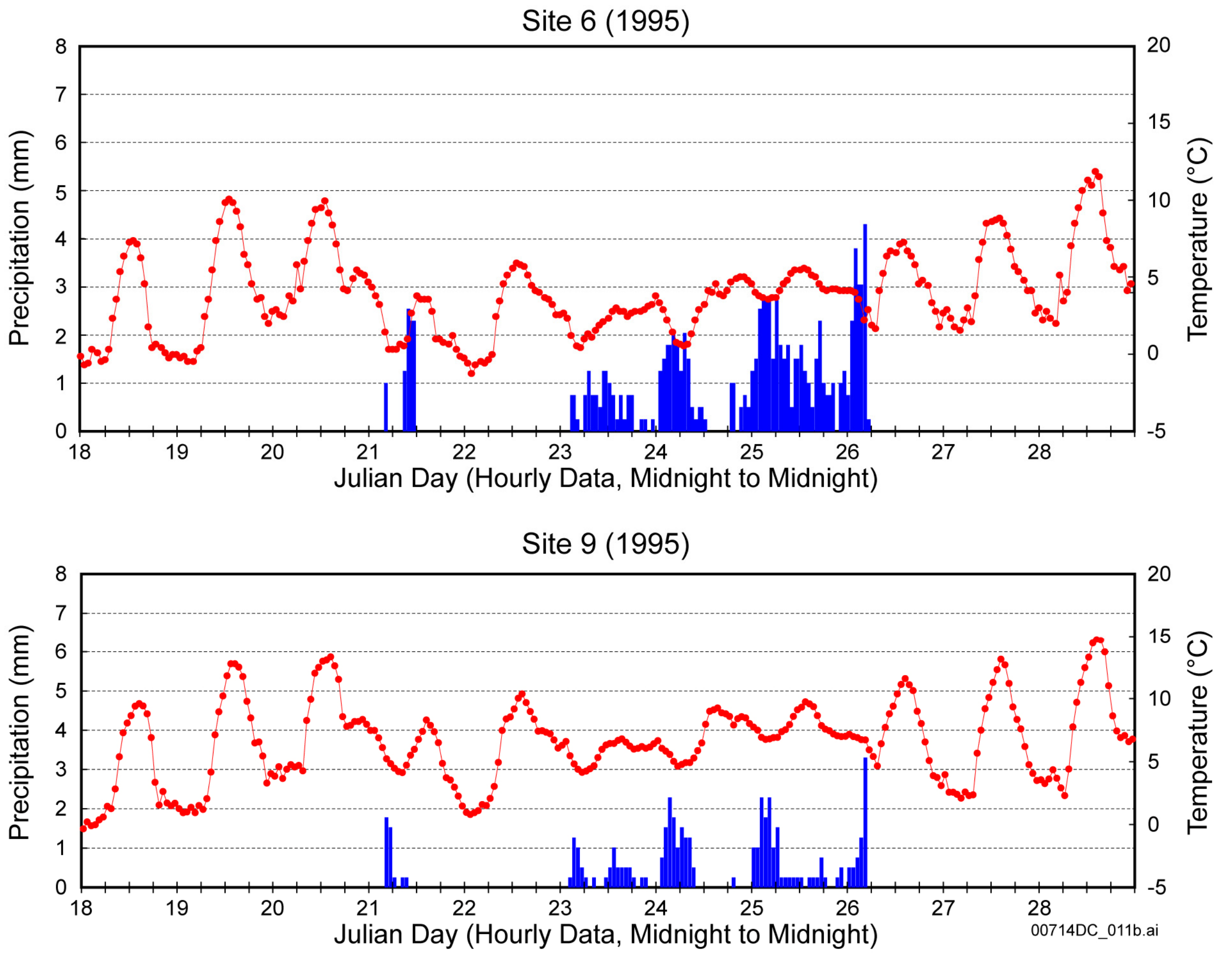
Figure D-2c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 8 through 12 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

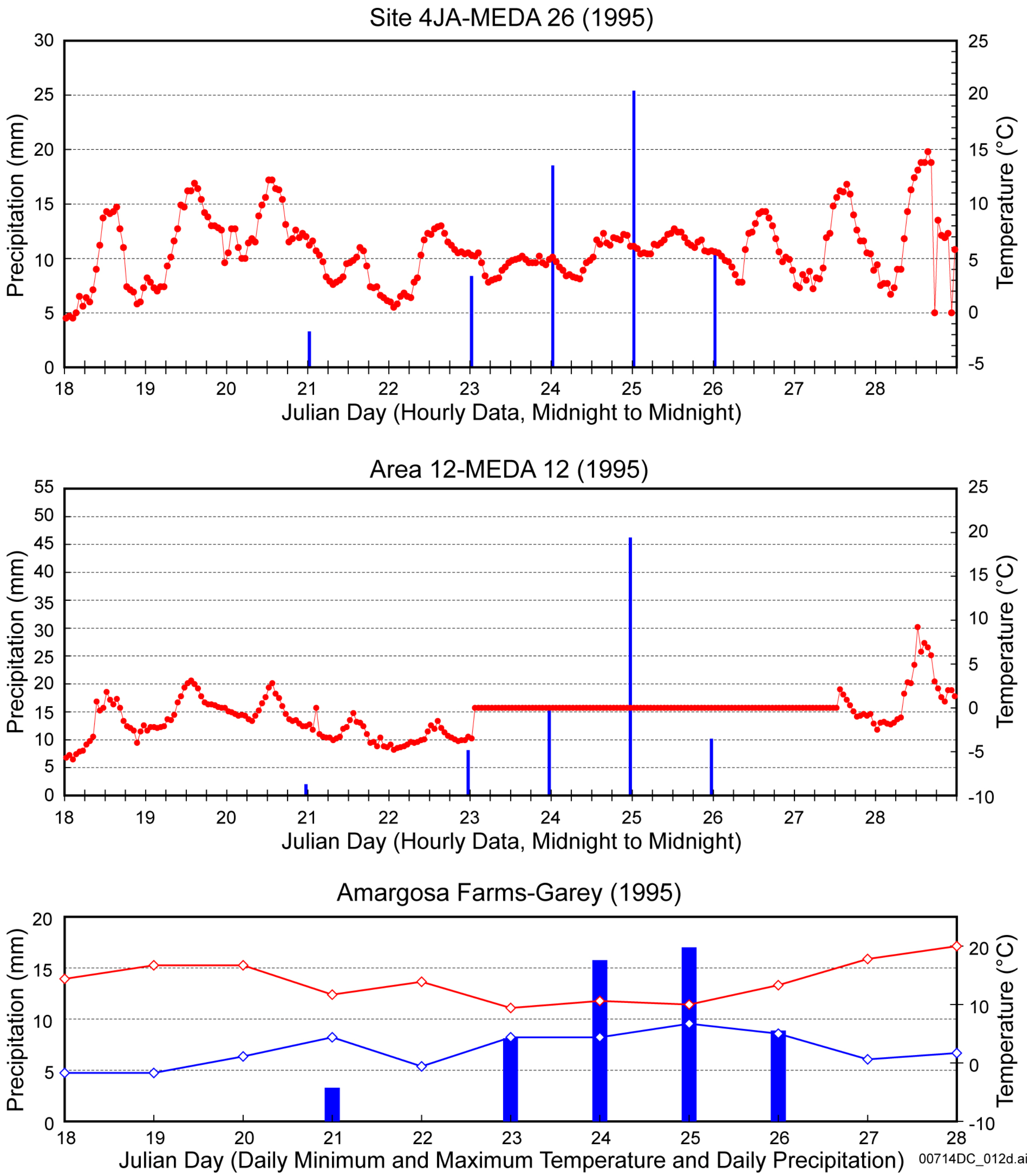
Figure D-3a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 18 through 28 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

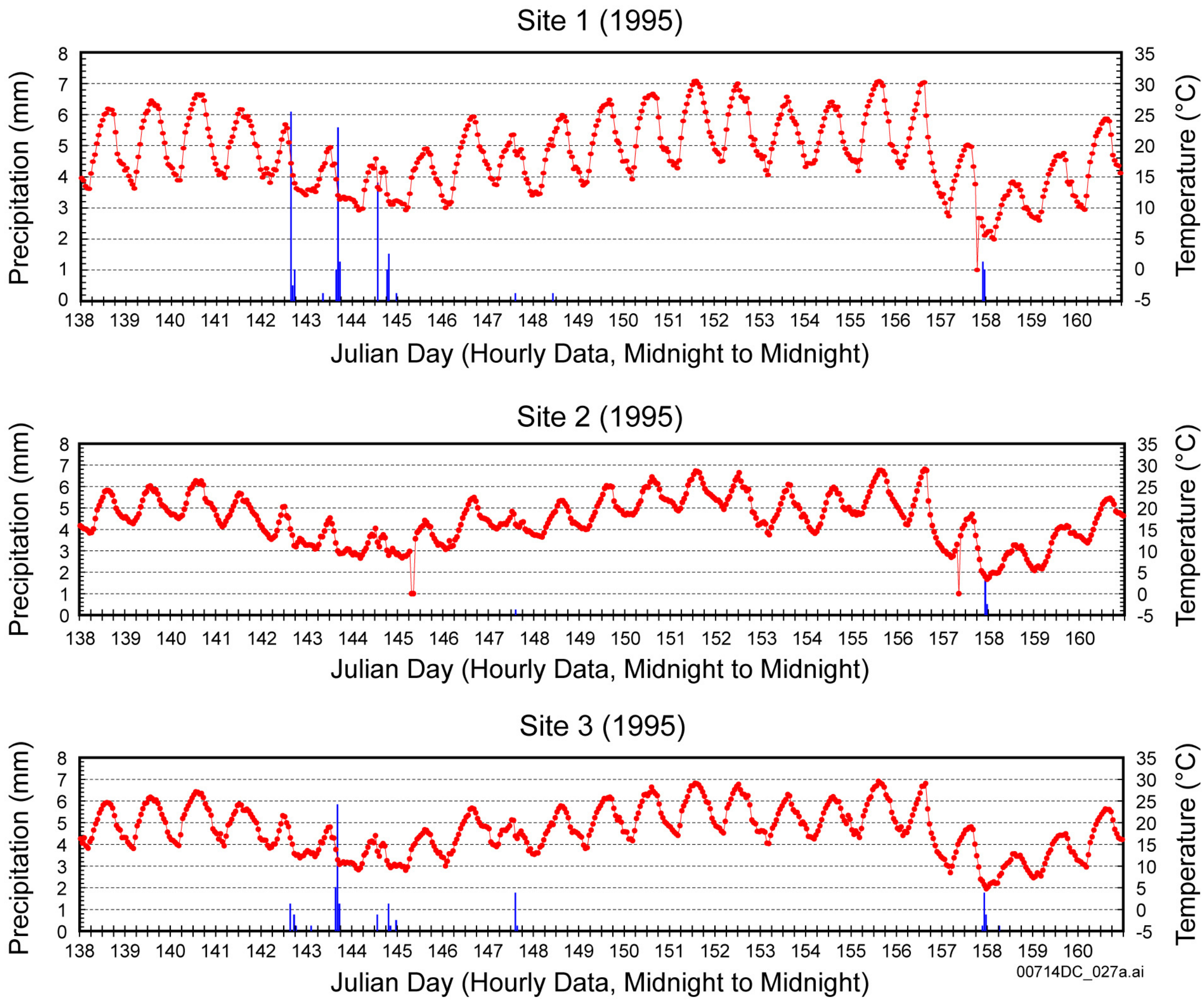
Figure D-3b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 18 through 28 in 1995



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
A plateau in the temperature data represents missing data.
Plots may vary in format and range.

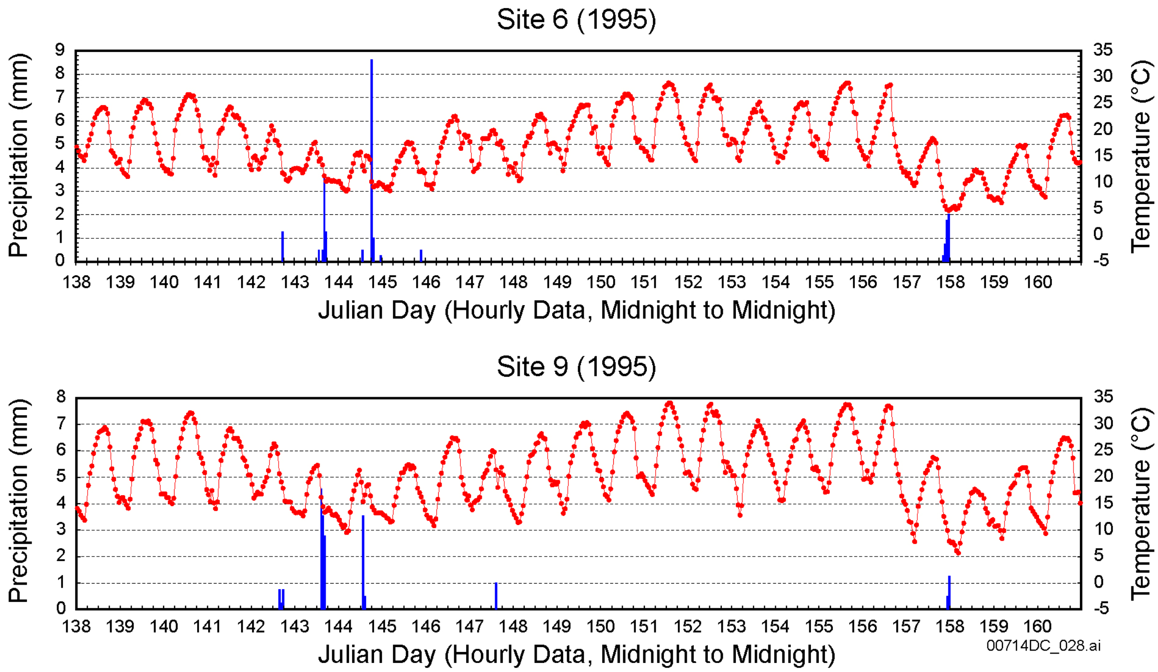
Figure D-3c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 18 through 28 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

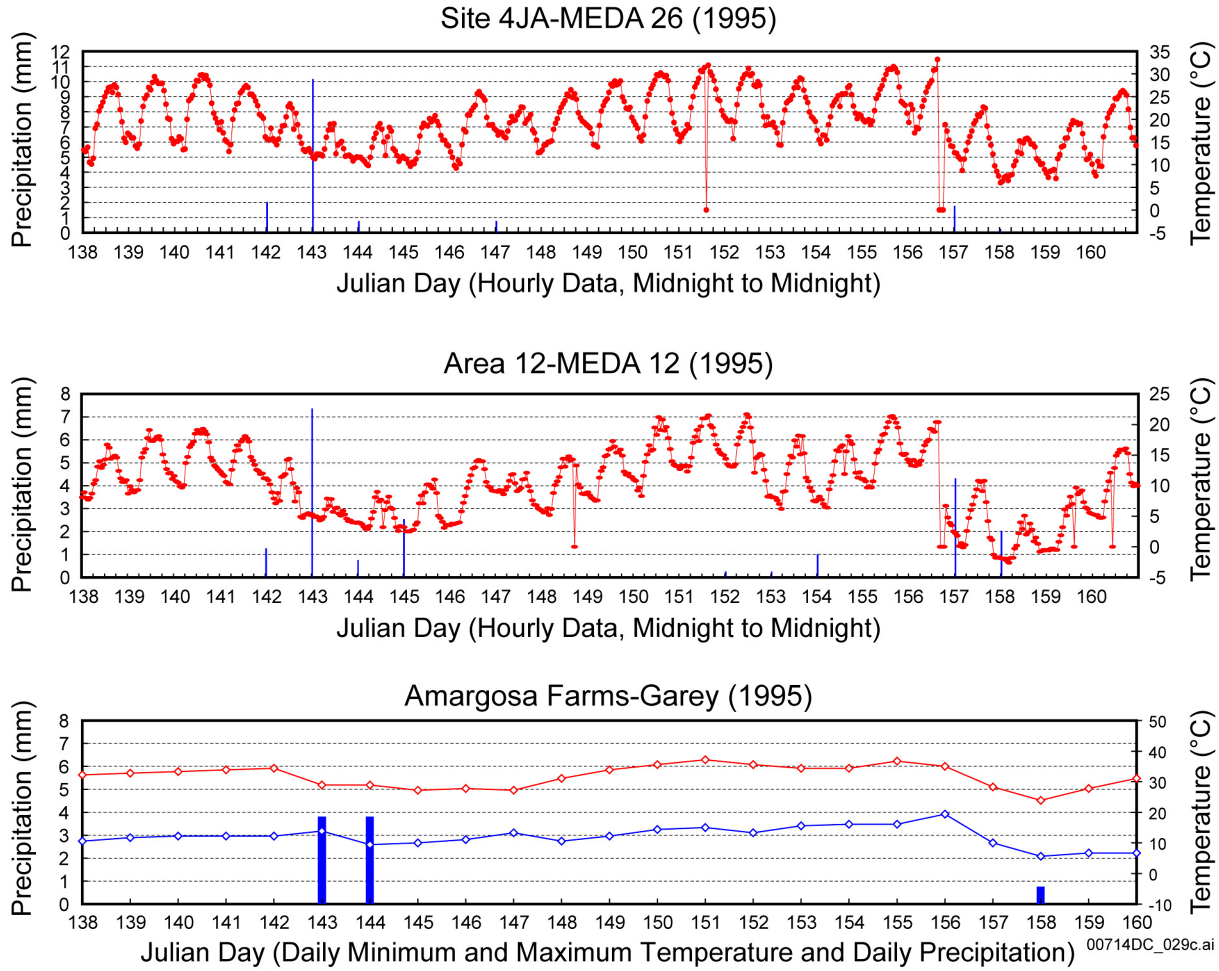
Figure D-4a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 138 through 160 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

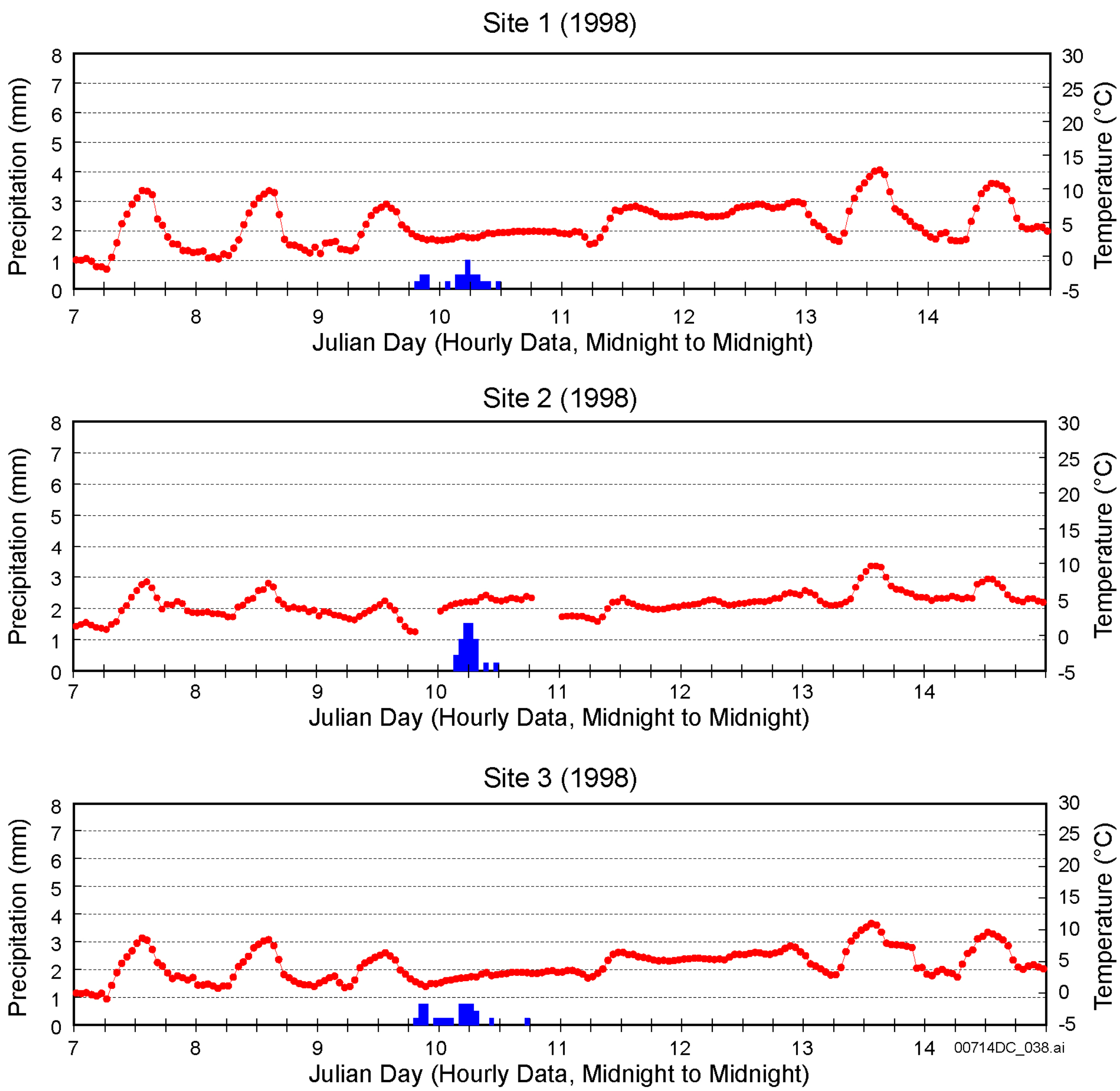
Figure D-4b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 138 through 160 in 1995



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

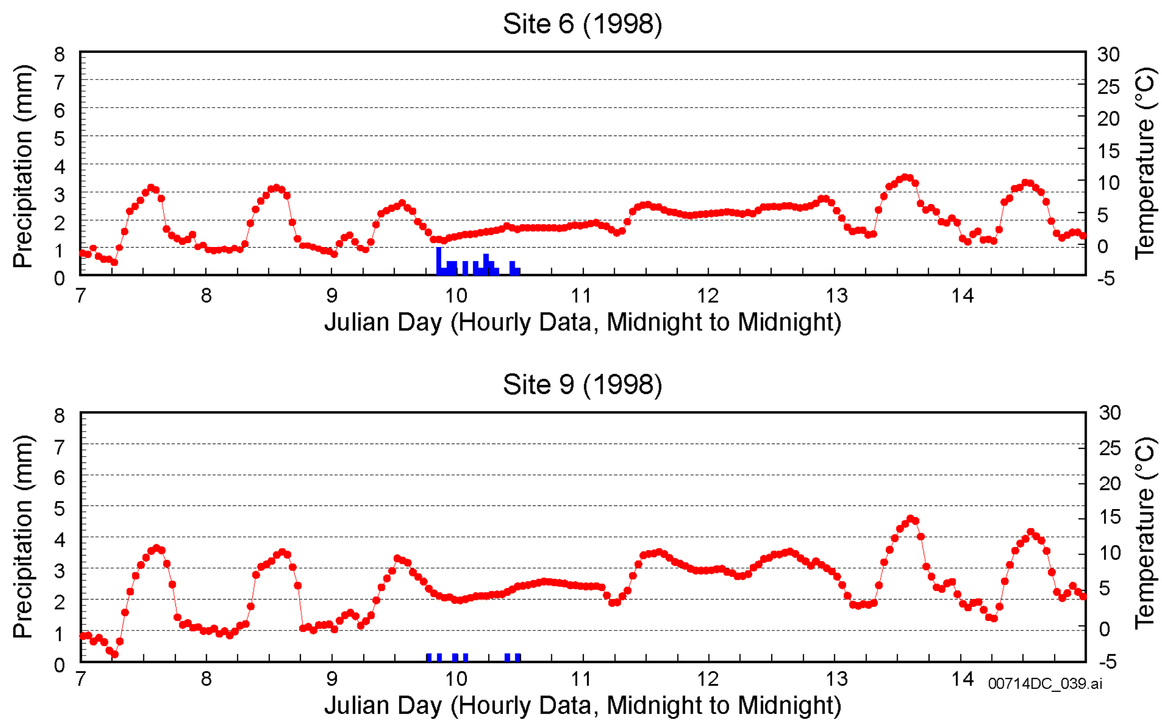
Figure D-4c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 138 through 160 in 1995



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Gaps in the temperature data represent N/A data (missing data). Plots may vary in format and range.

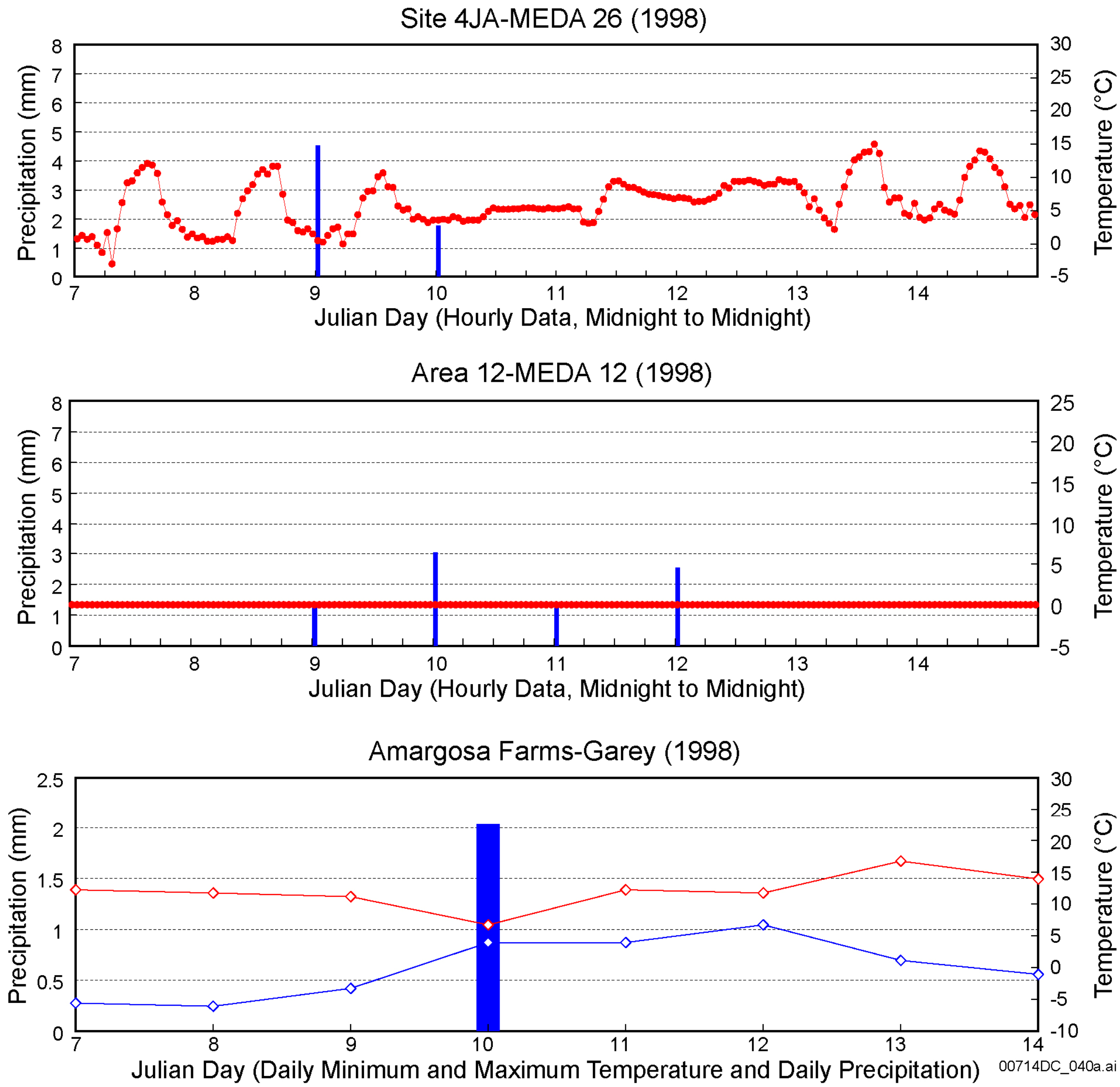
Figure D-5a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 7 through 14 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

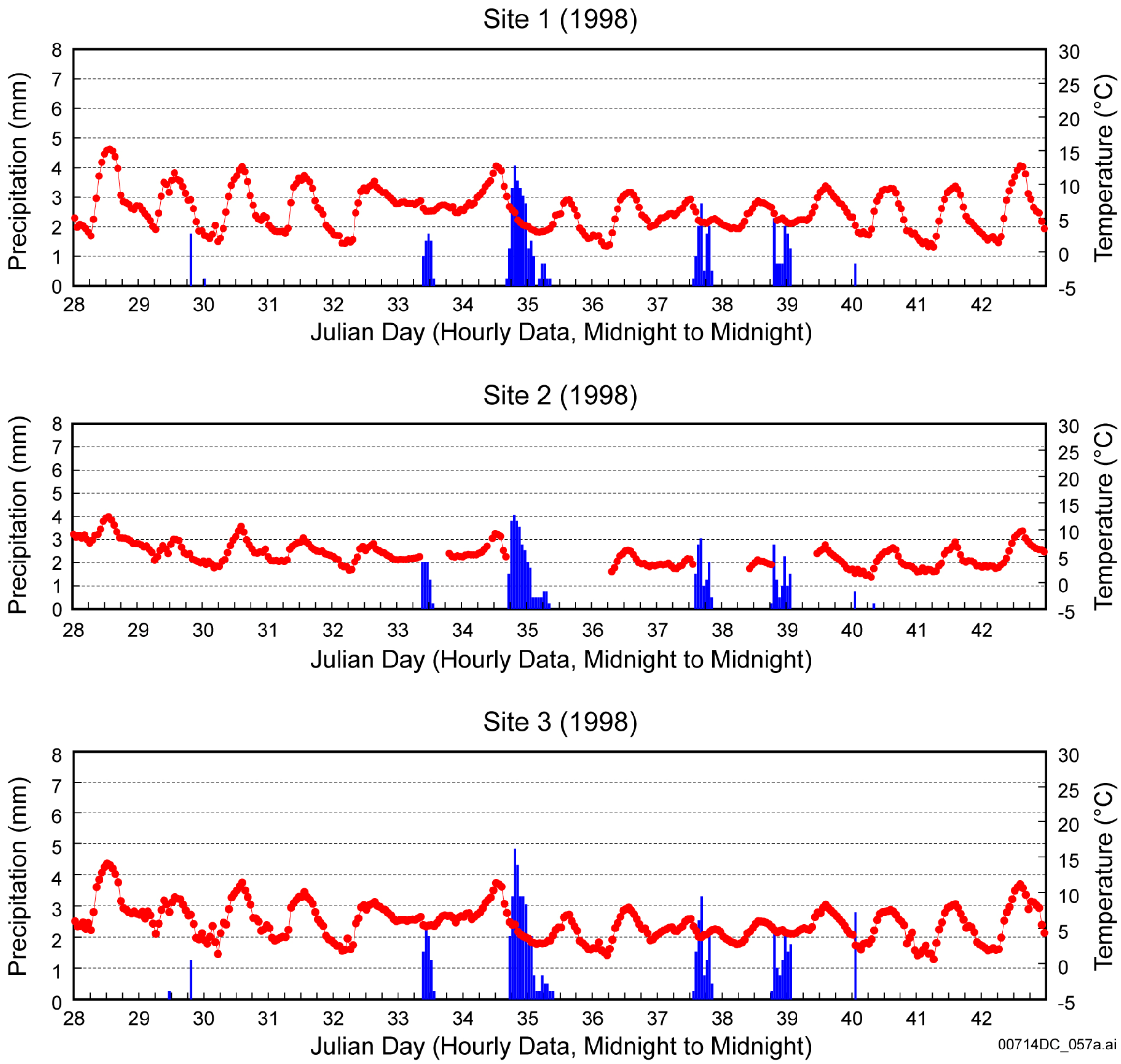
Figure D-5b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 7 through 14 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Temperature data for Area 12–MEDA 12 were recorded as N/A (missing data).
Plots may vary in format and range.

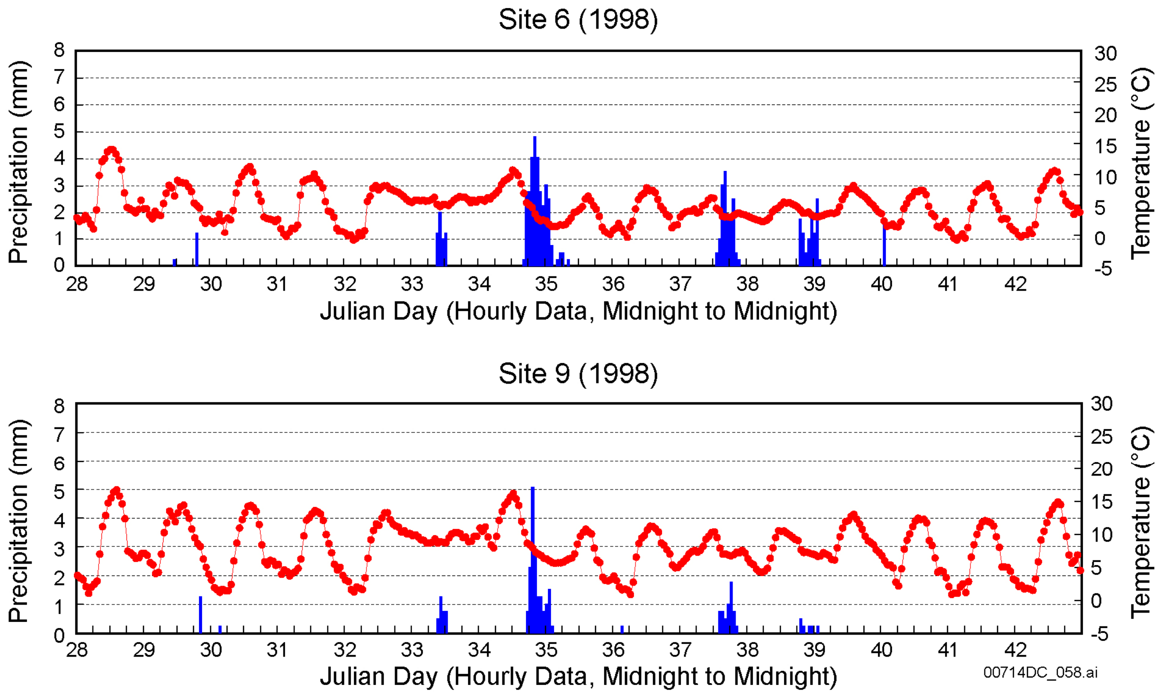
Figure D-5c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 7 through 14 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Gaps in the temperature data represent a record marked N/A (missing data). Plots may vary in format and range.

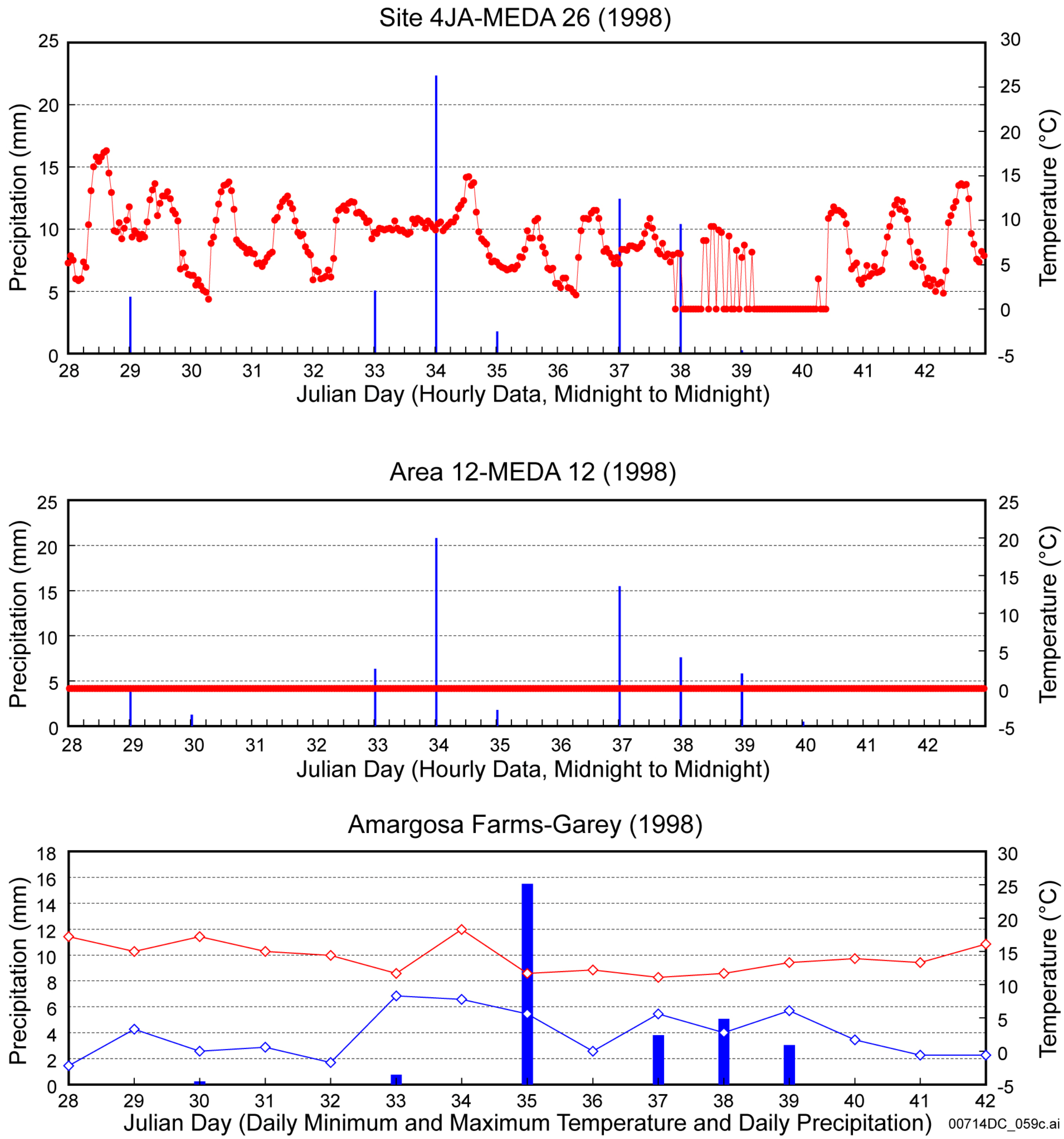
Figure D-6a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 28 through 42 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

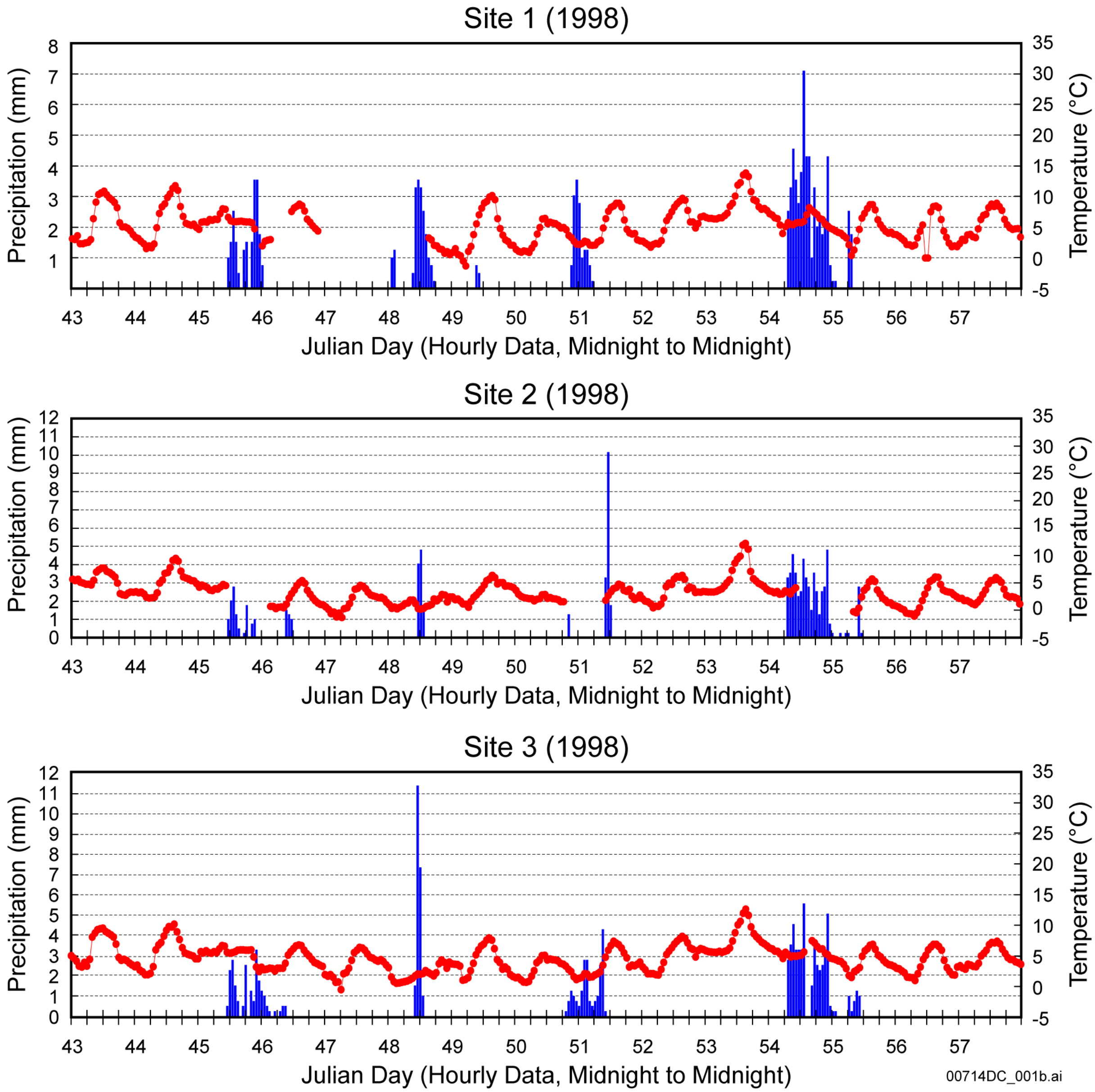
Figure D-6b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 28 through 42 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Temperature readings of zero were recorded as N/A from the temperature data (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

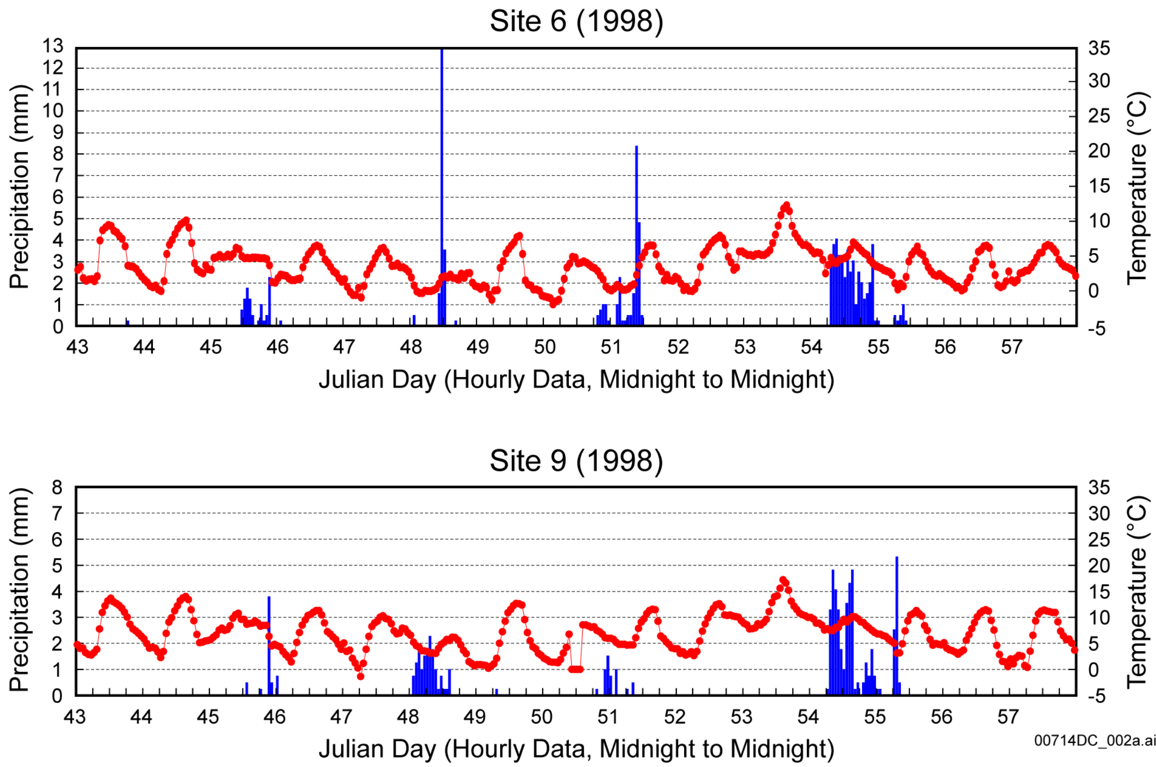
Figure D-6c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 28 through 42 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. A gap in temperature data represents a N/A recording (missing data). Plots may vary in format and range.

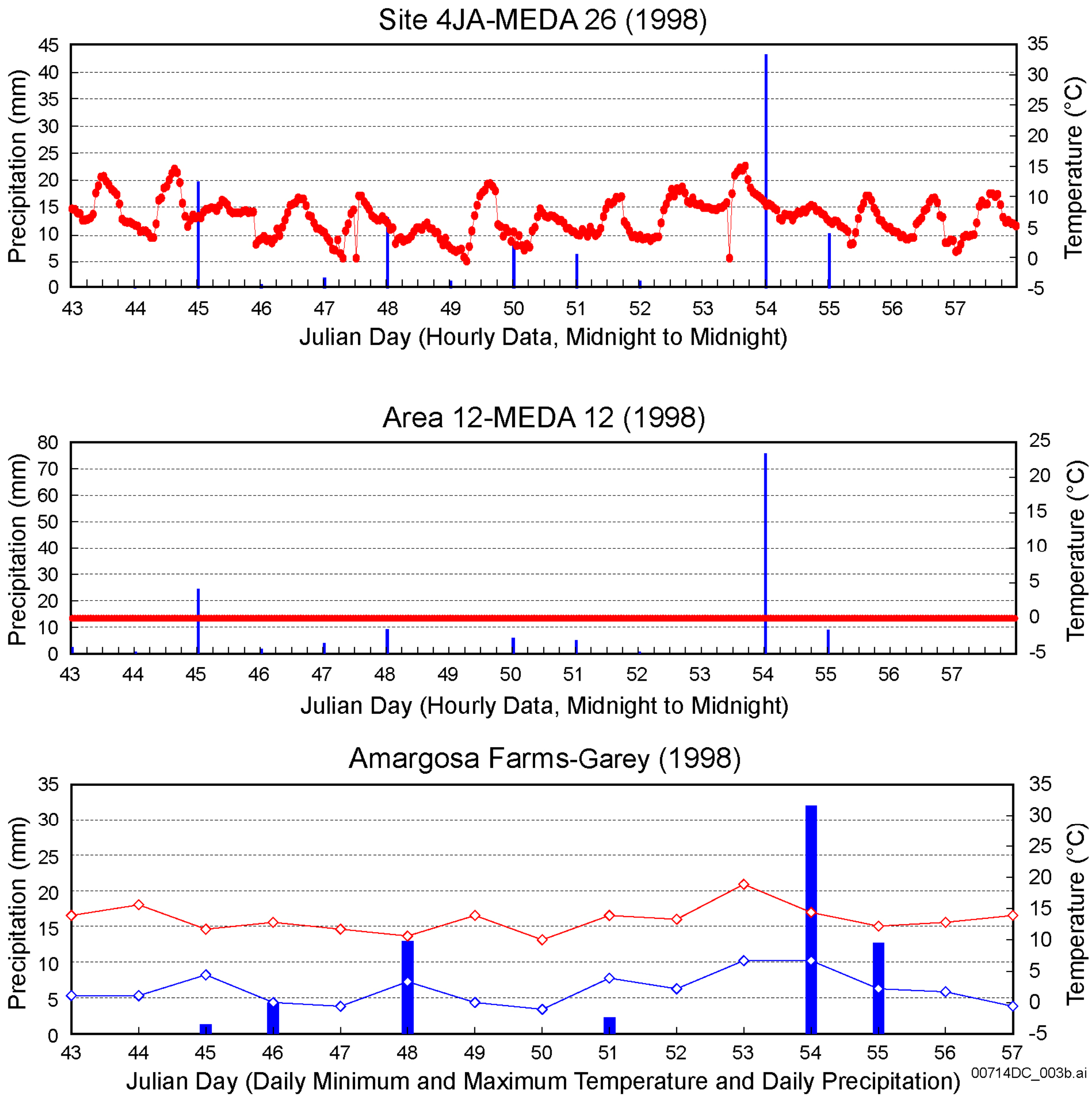
Figure D-7a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 43 through 57 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

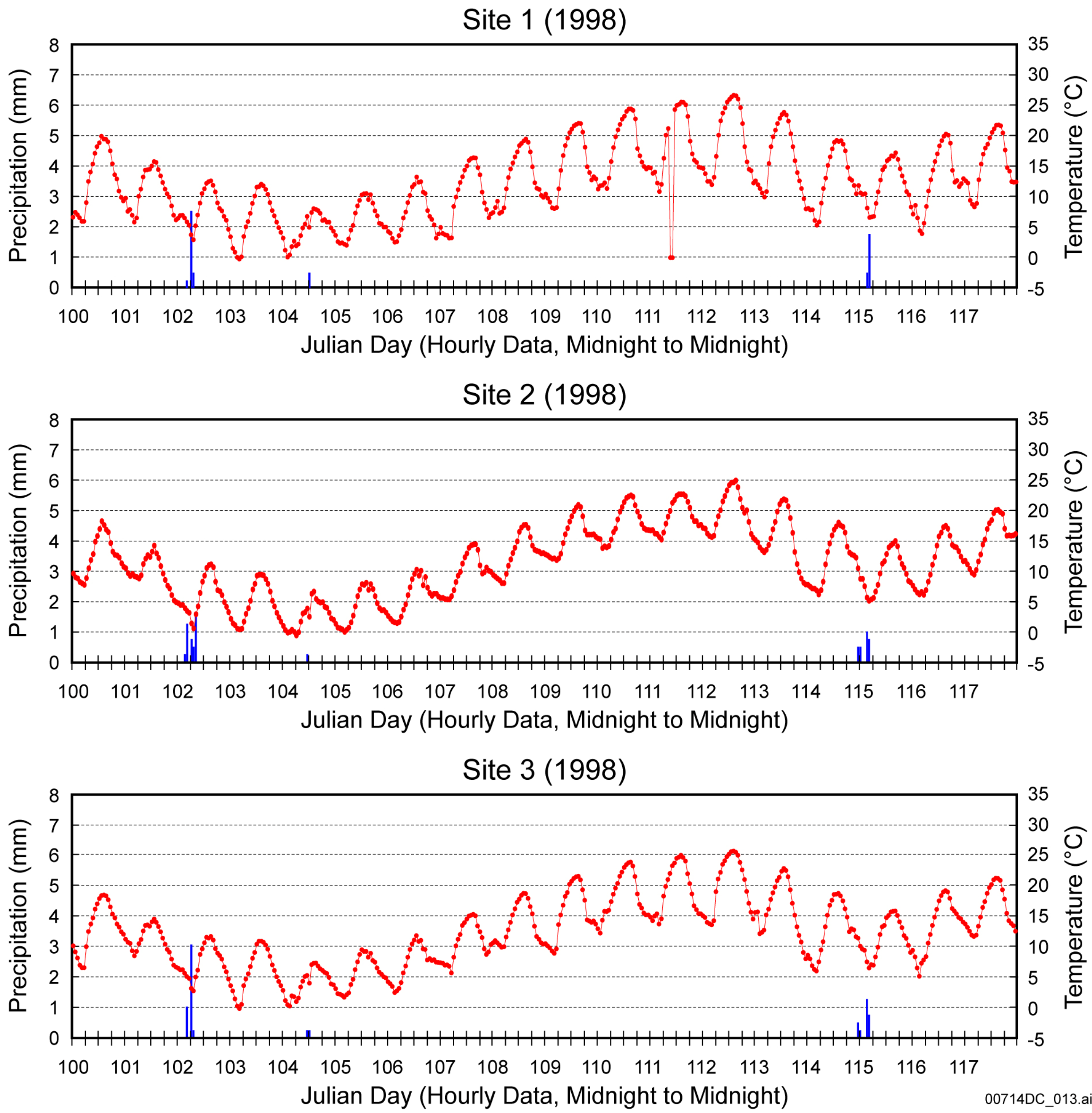
Figure D-7b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 43 through 57 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Temperature data plotted as zero were recorded as N/A (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

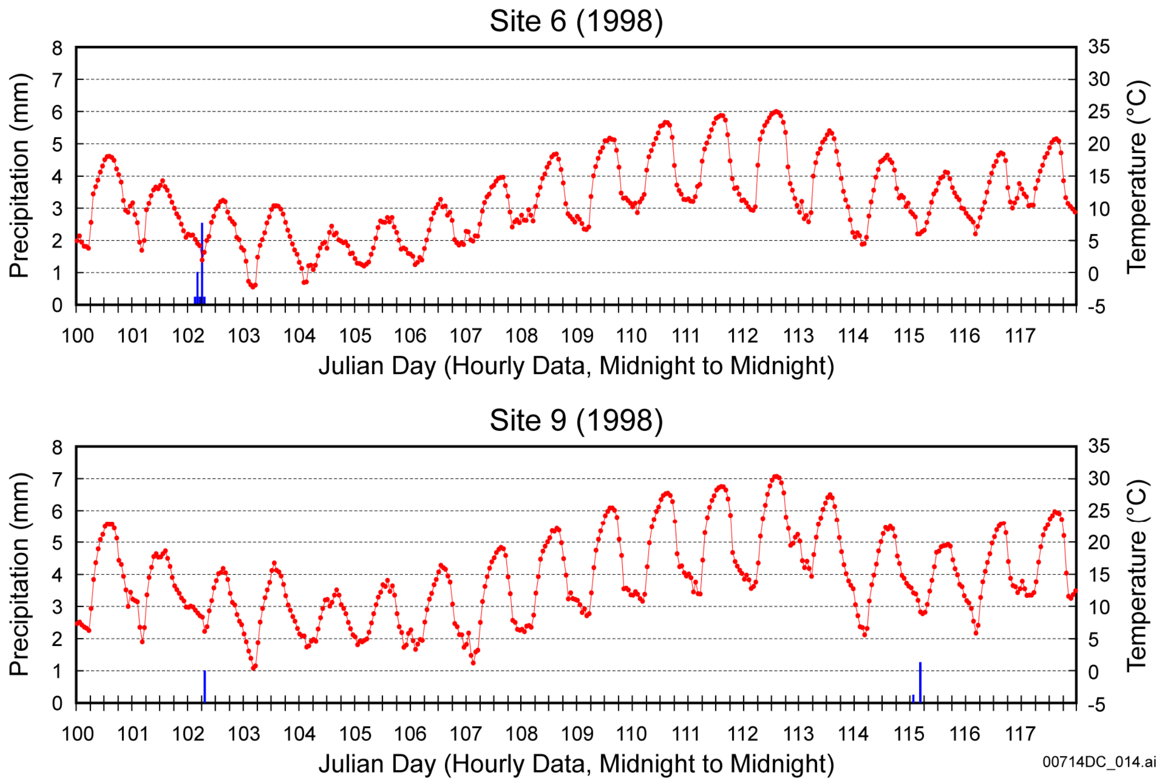
Figure D-7c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 43 through 57 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

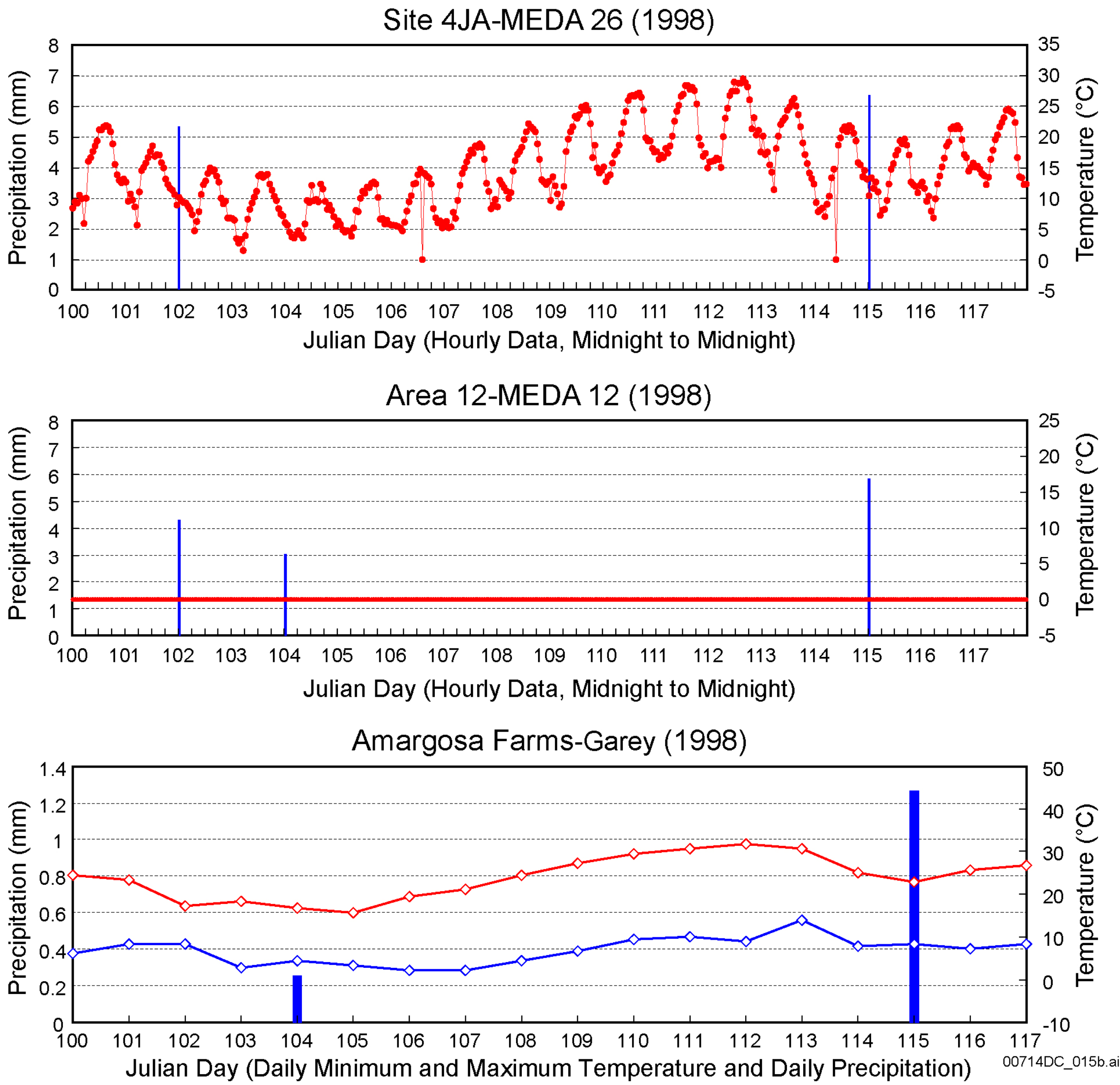
Figure D-8a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 100 through 117 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

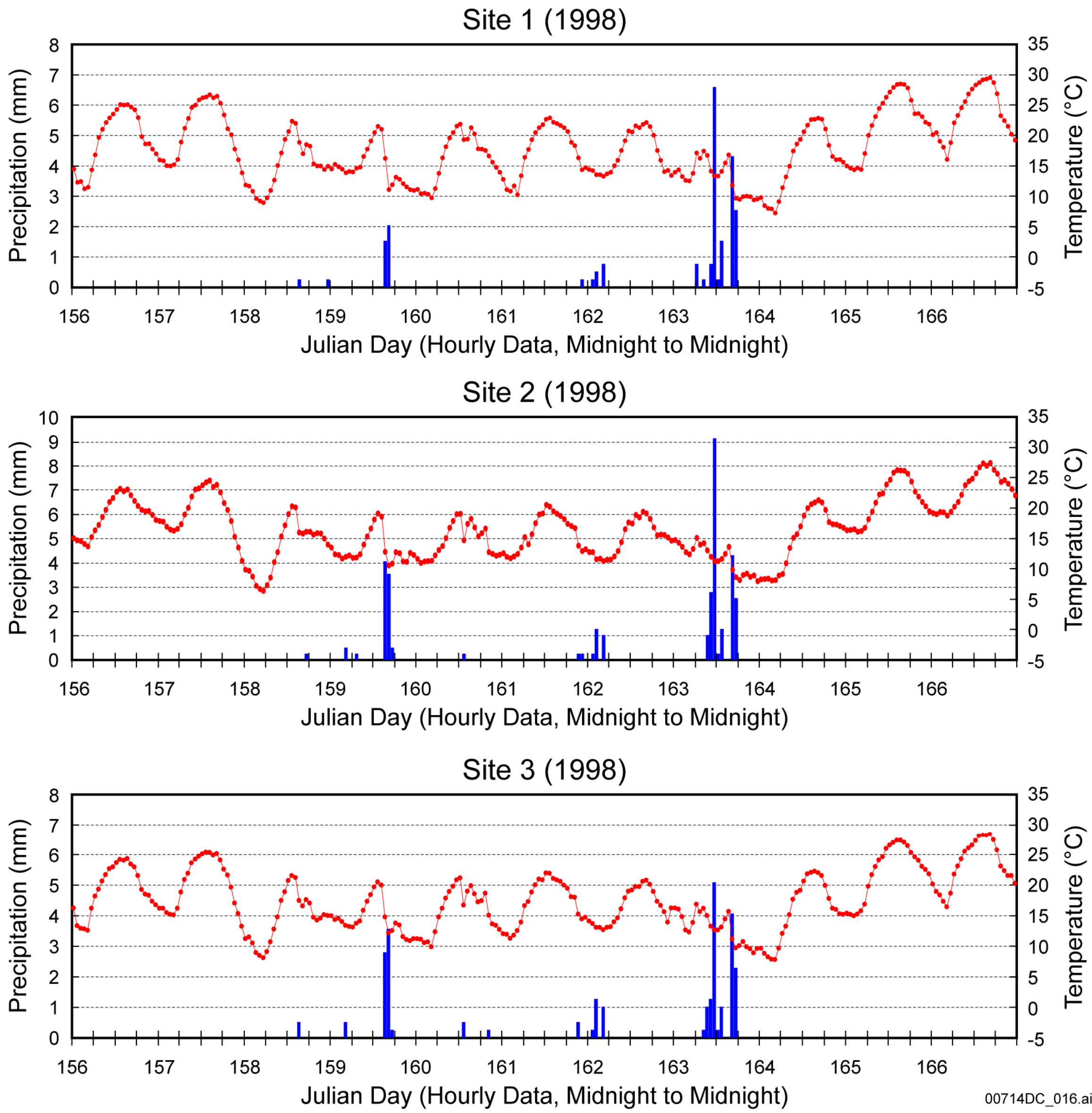
Figure D-8b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 100 through 117 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Temperatures plotted as zero were recorded as N/A (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

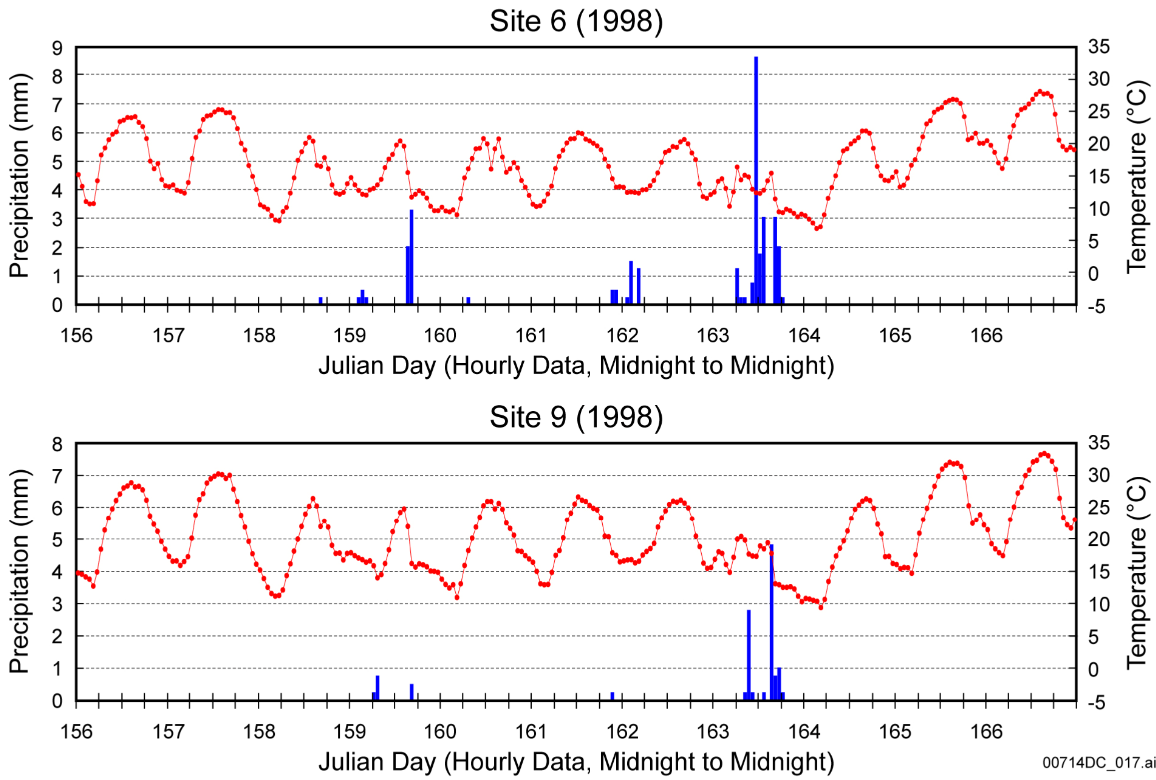
Figure D-8c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 100 through 117 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

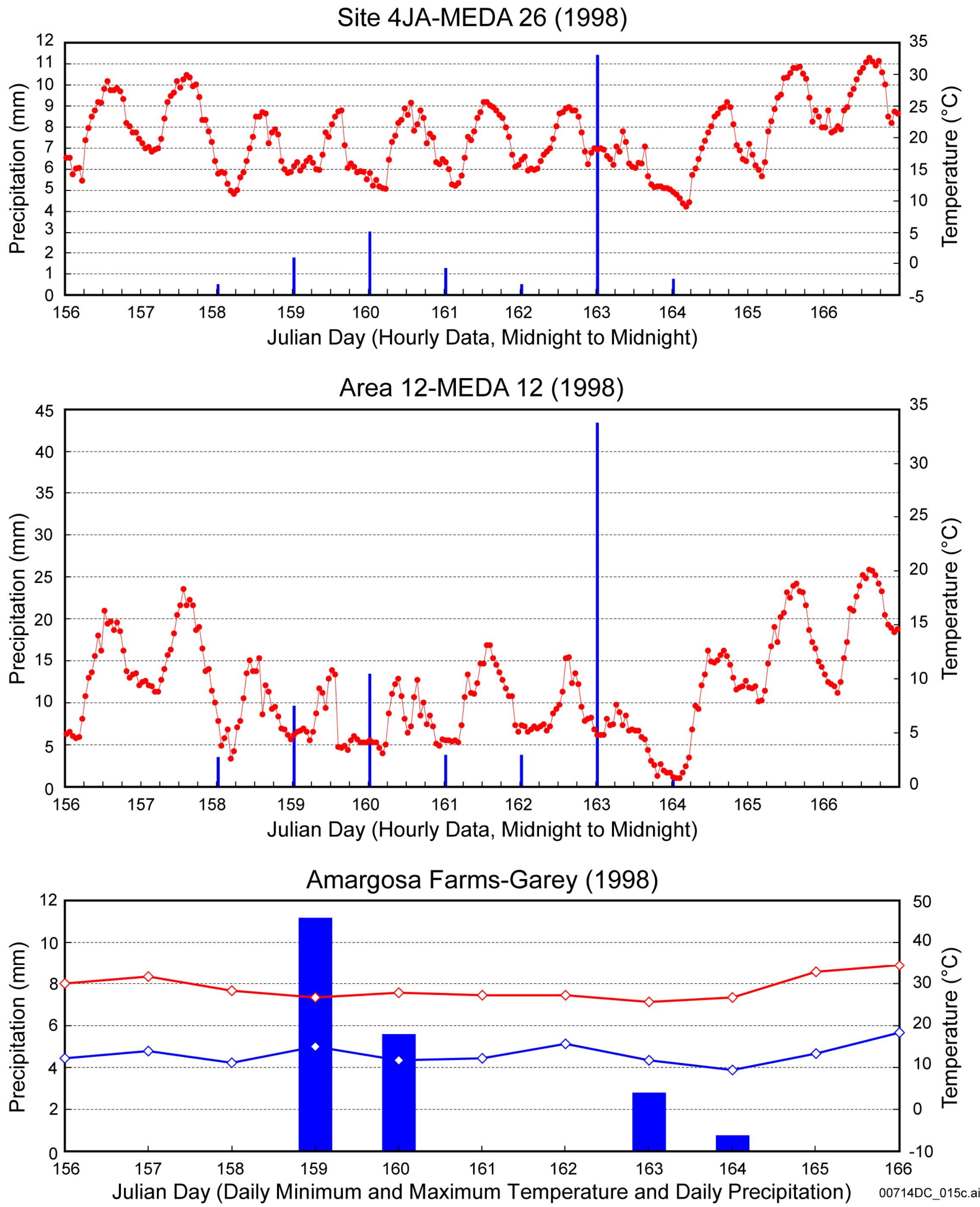
Figure D-9a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 156 through 166 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

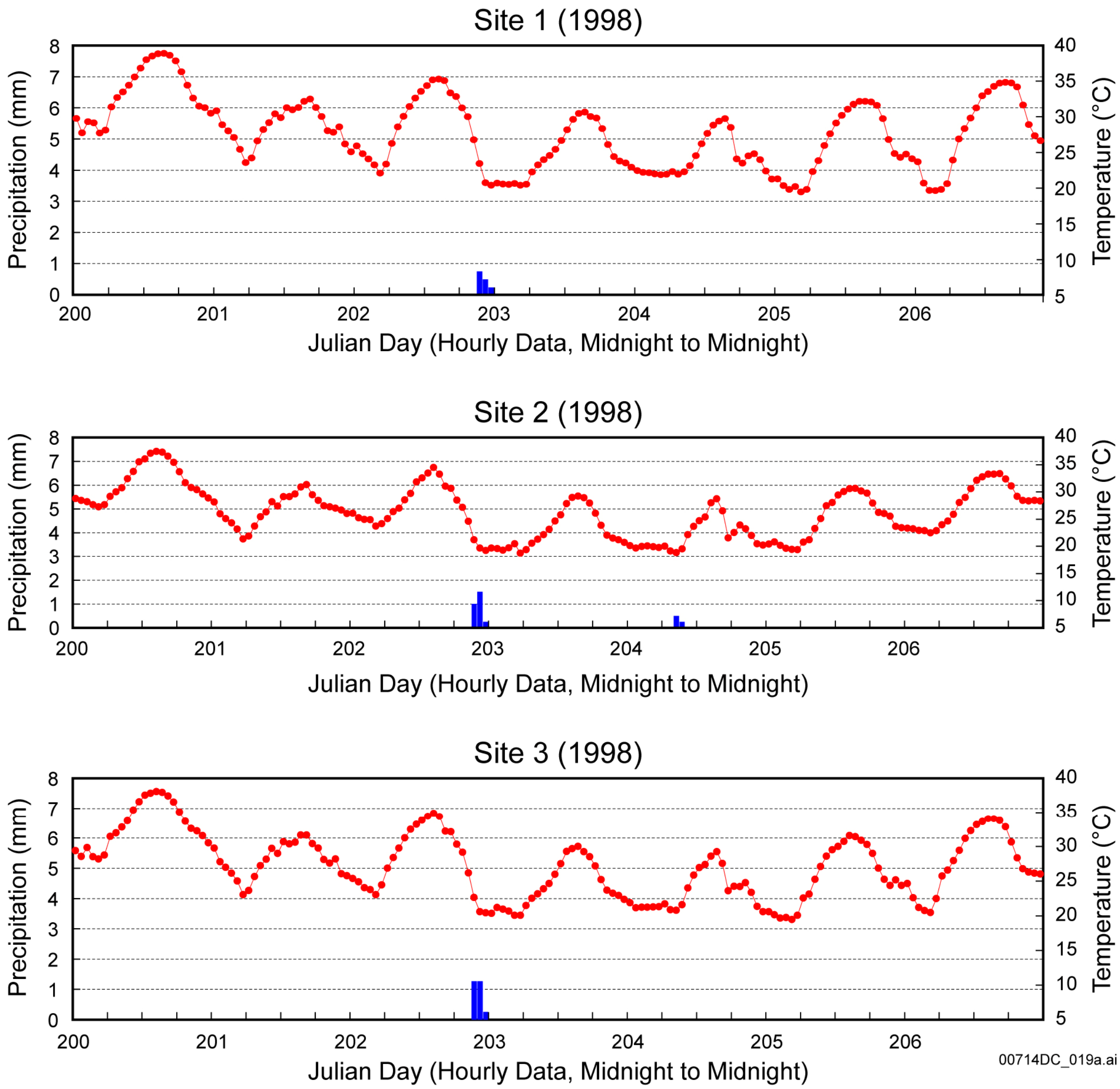
Figure D-9b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 156 through 166 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

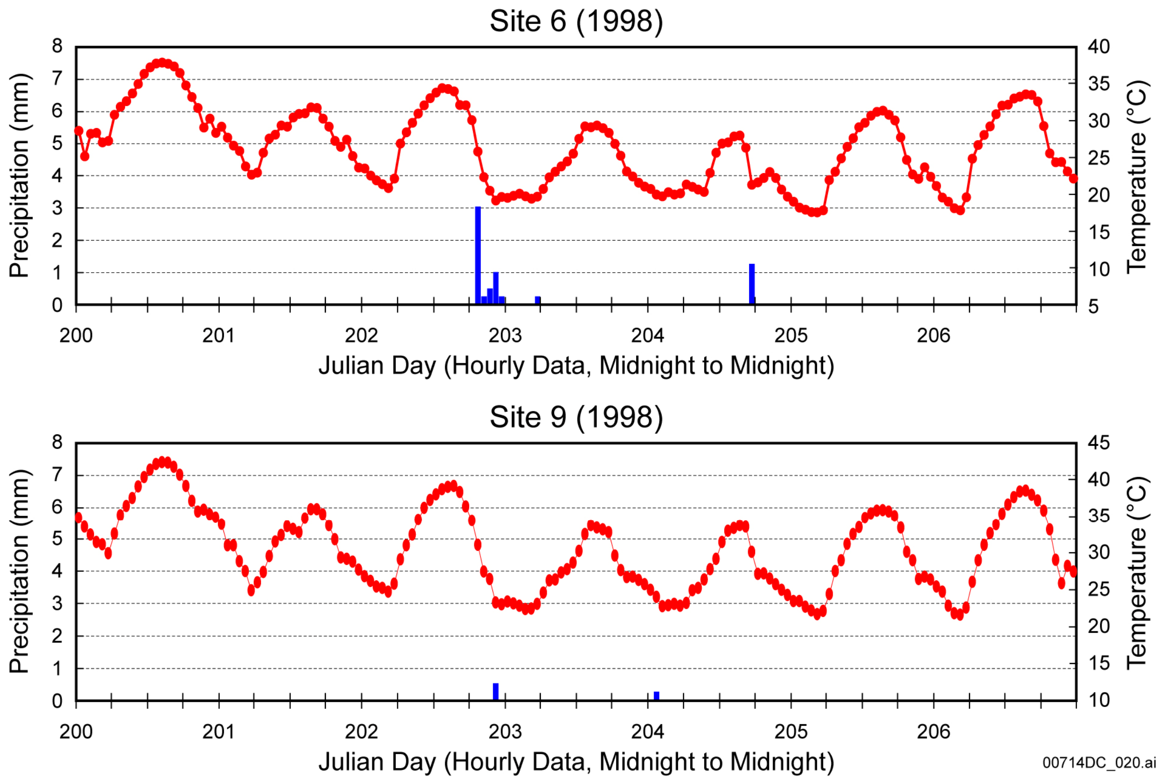
Figure D-9c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 156 through 166 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

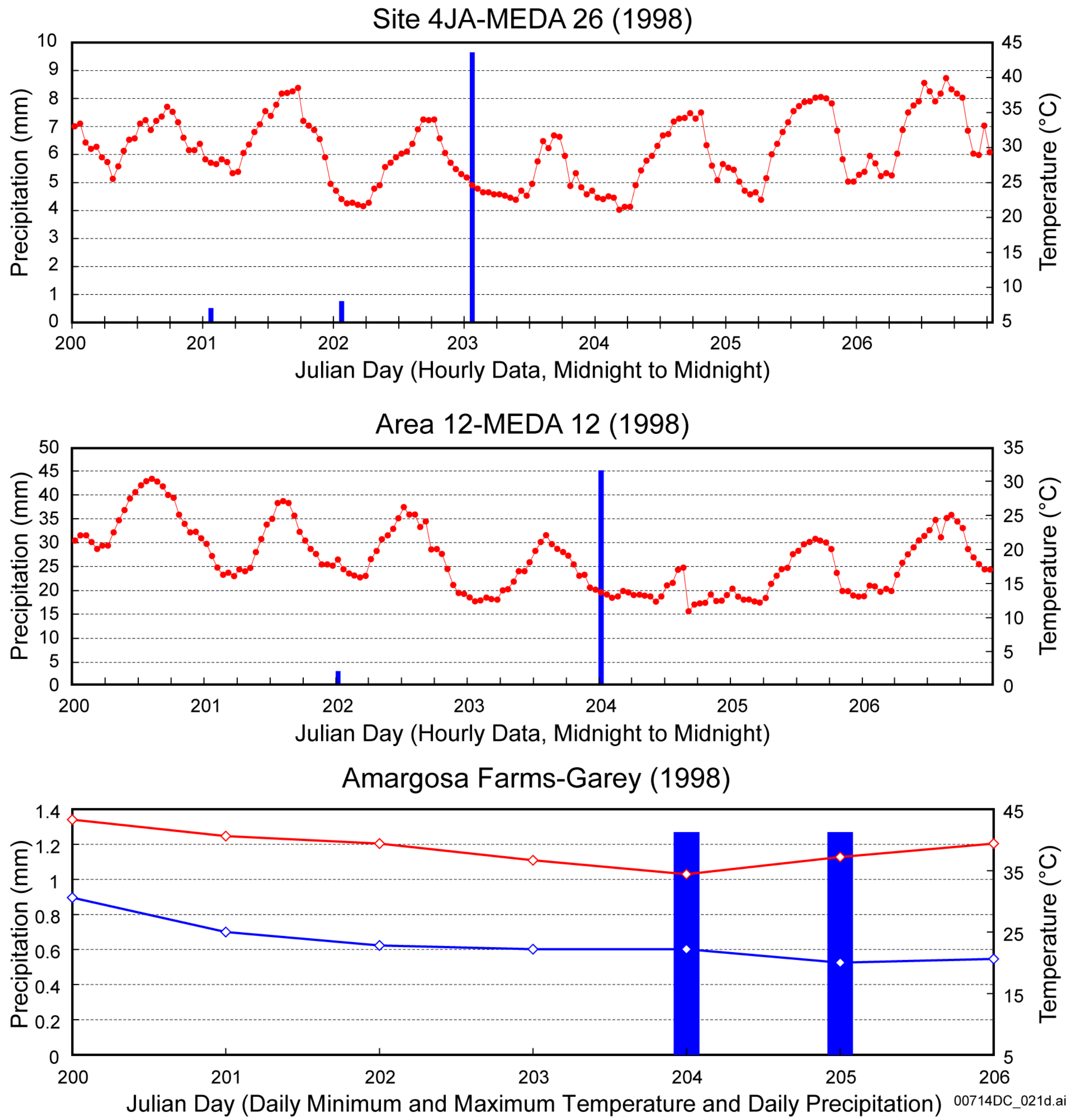
Figure D-10a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 200 through 206 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

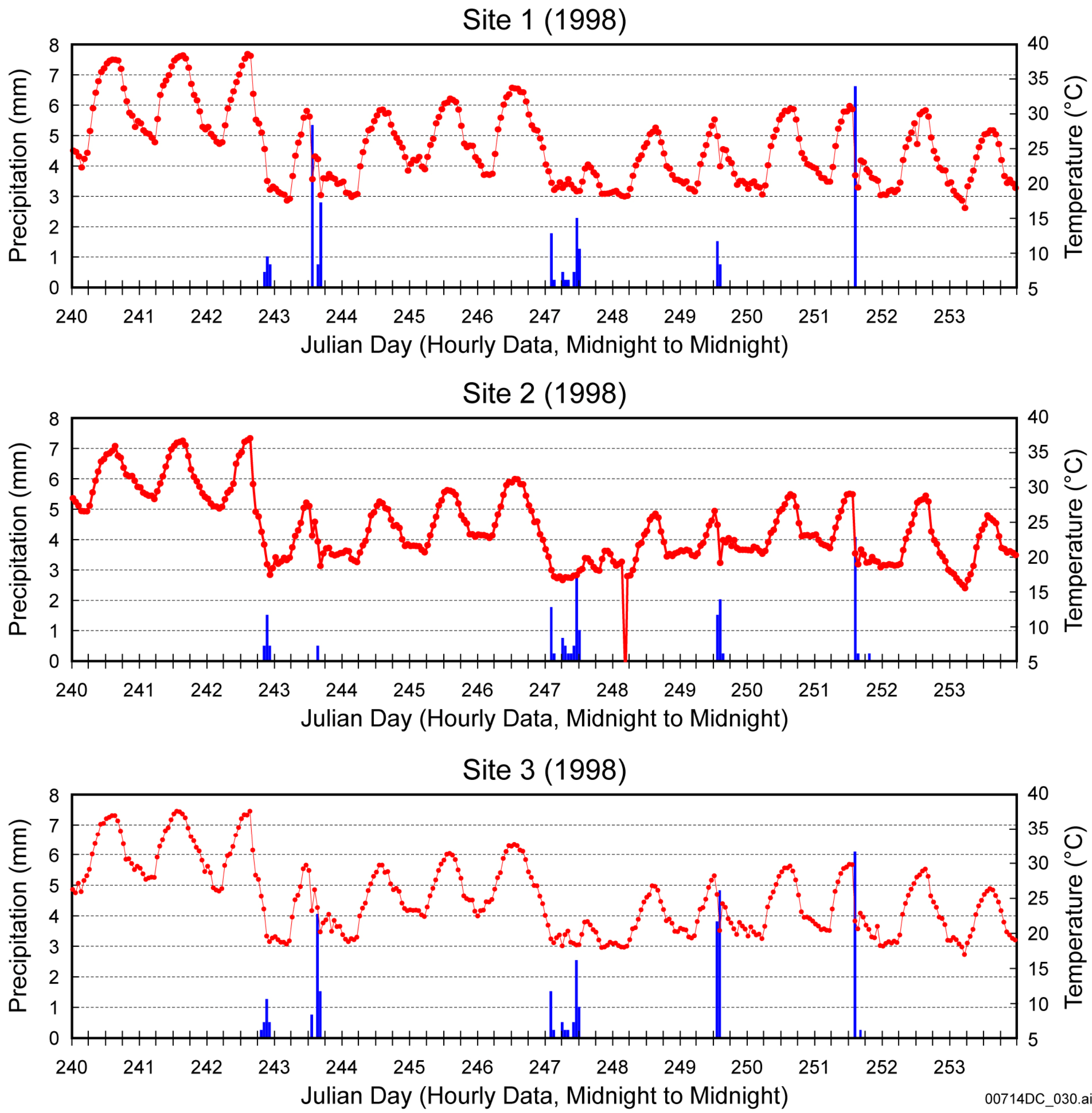
Figure D-10b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 200 through 206 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

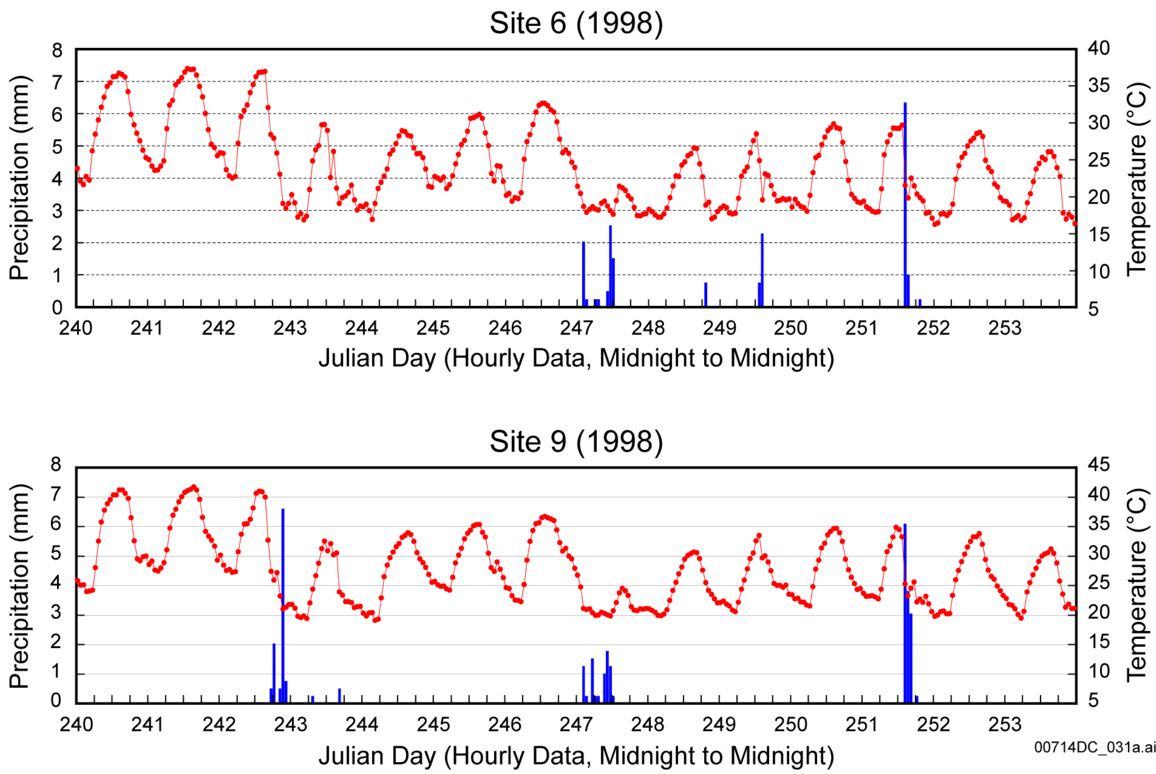
Figure D-10c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 200 through 206 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

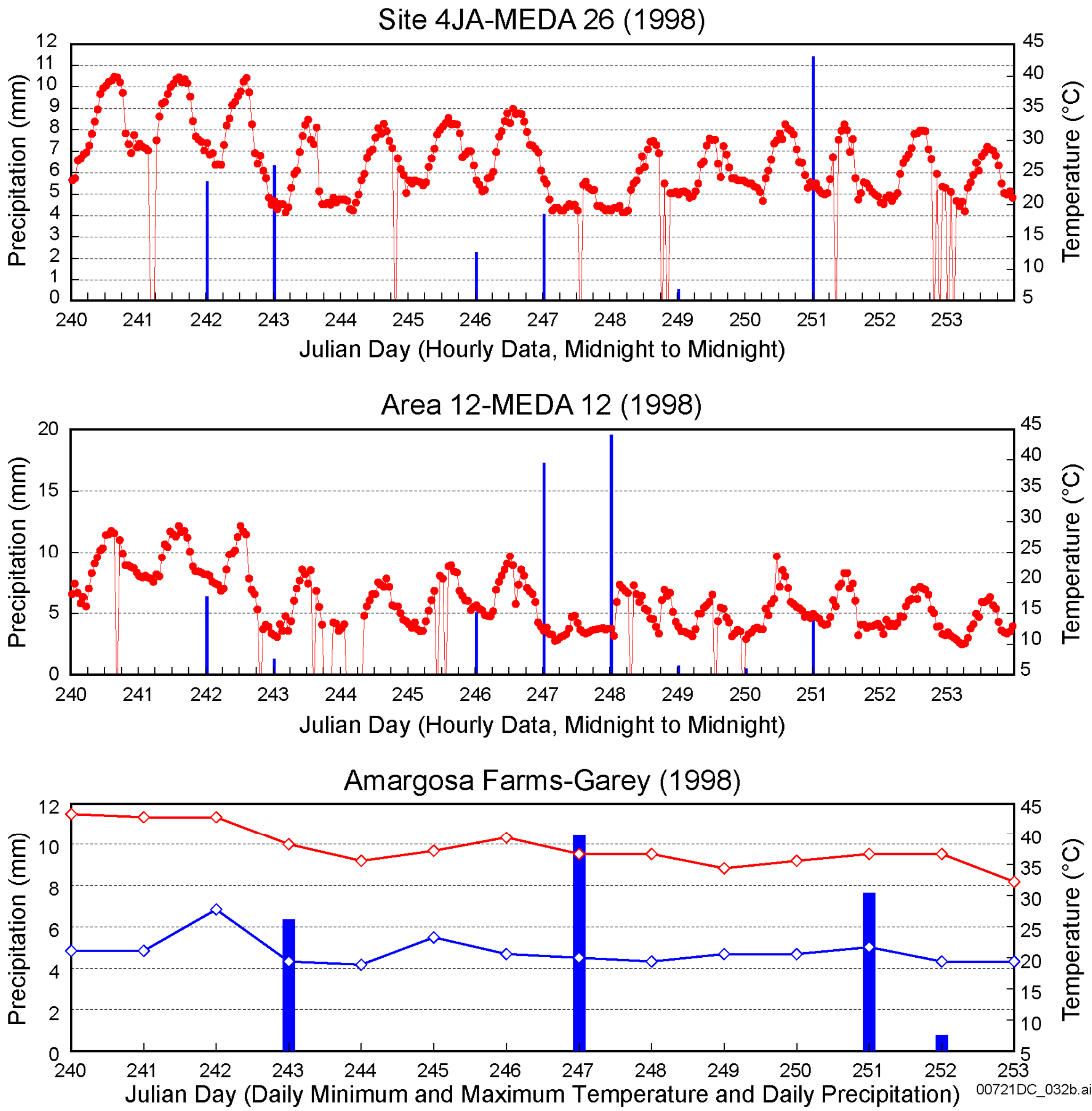
Figure D-11a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 240 through 253 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

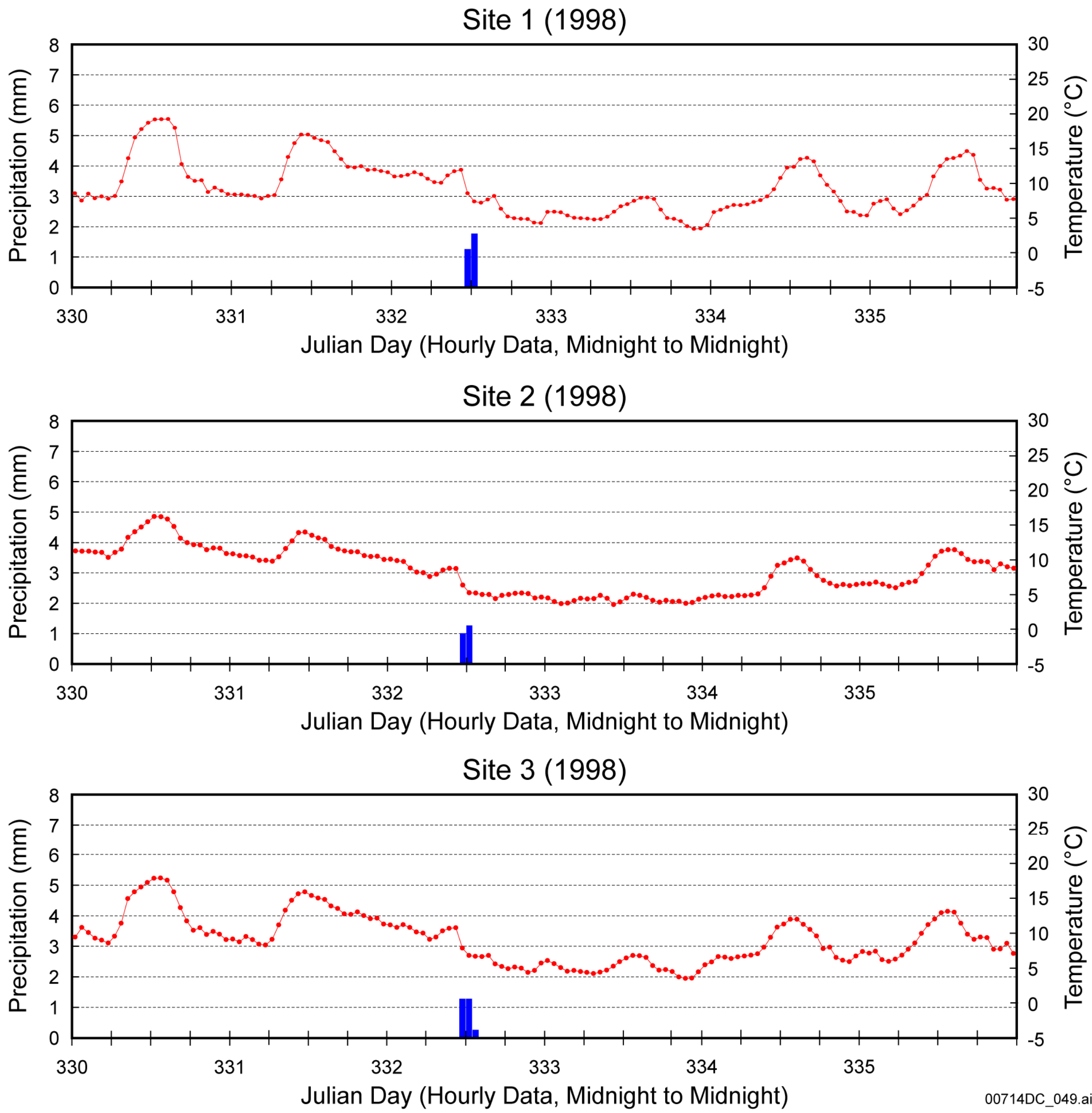
Figure D-11b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 240 through 253 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Temperature readings of zero (below graph range on applicable graphs) were N/A (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

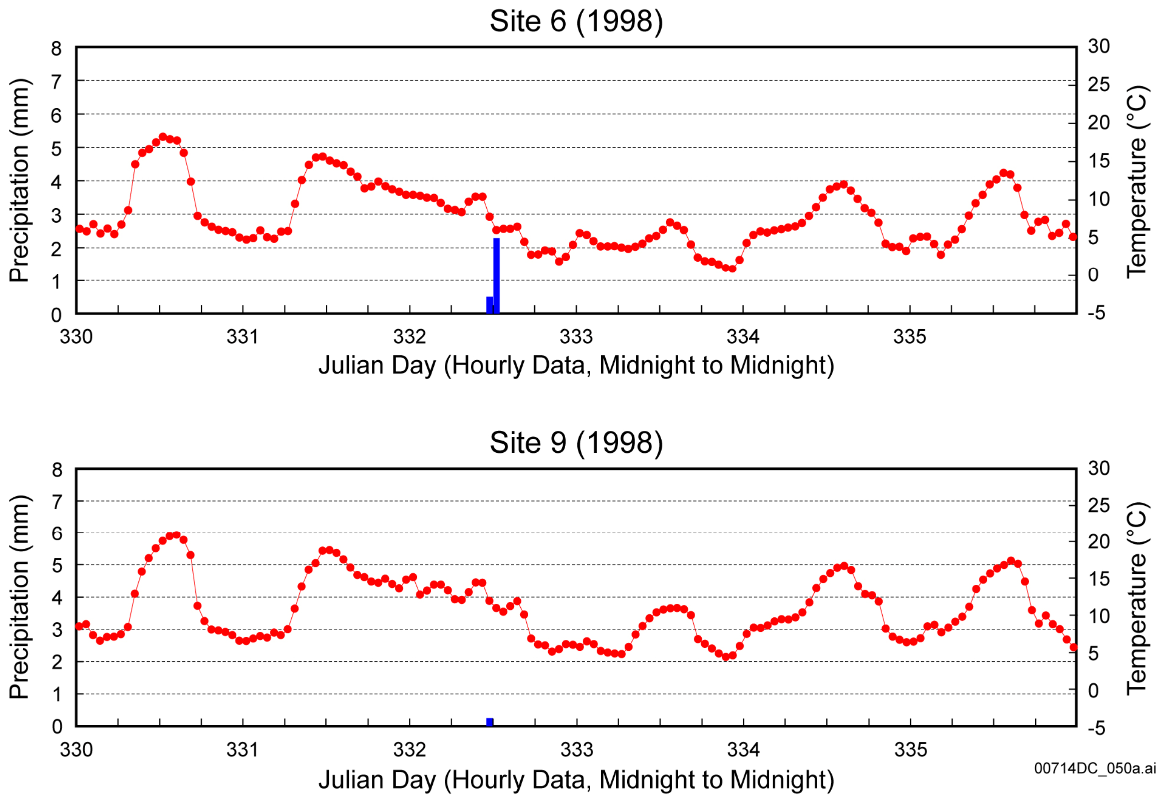
Figure D-11c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 240 through 253 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

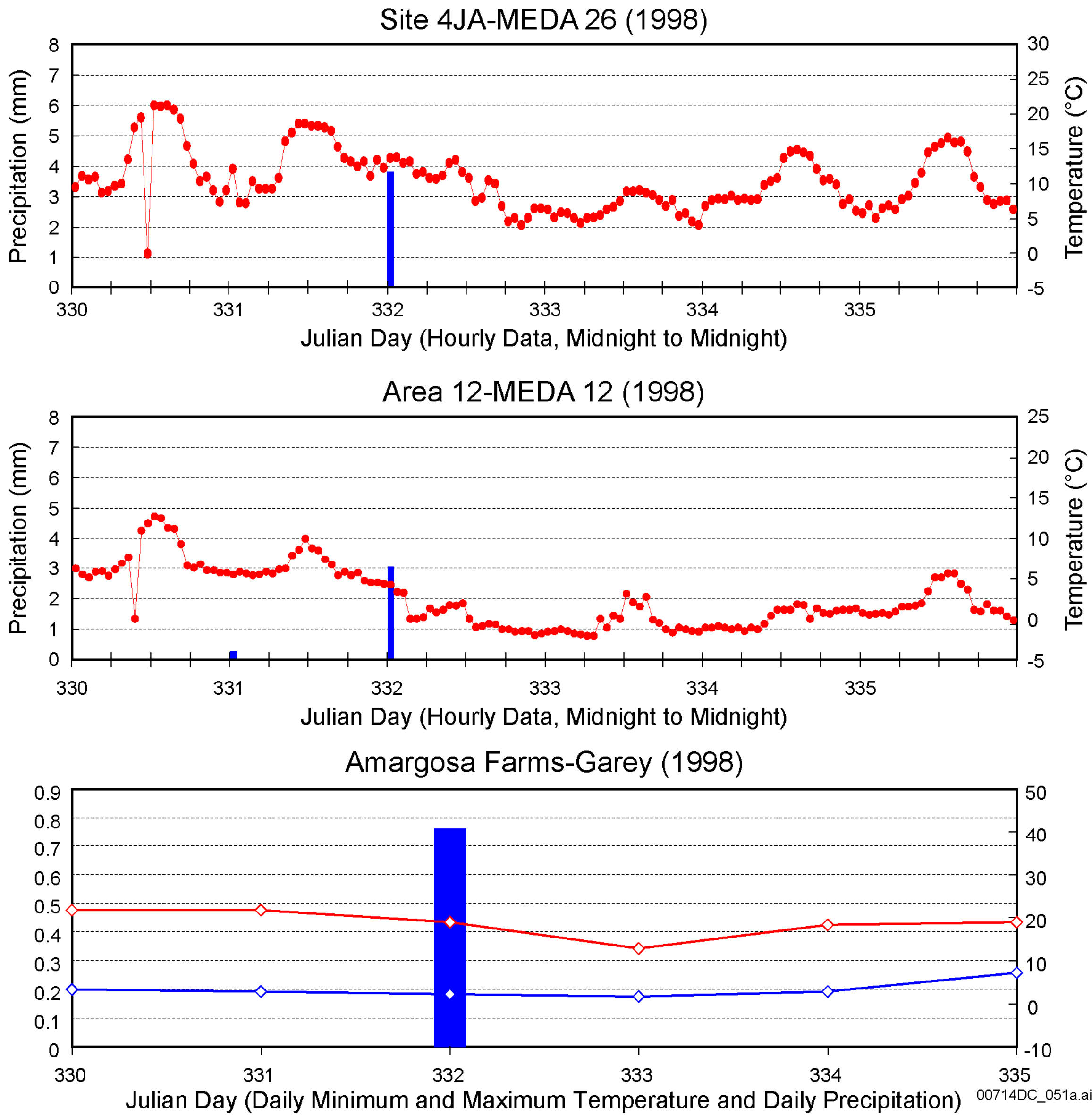
Figure D-12a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 330 through 335 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

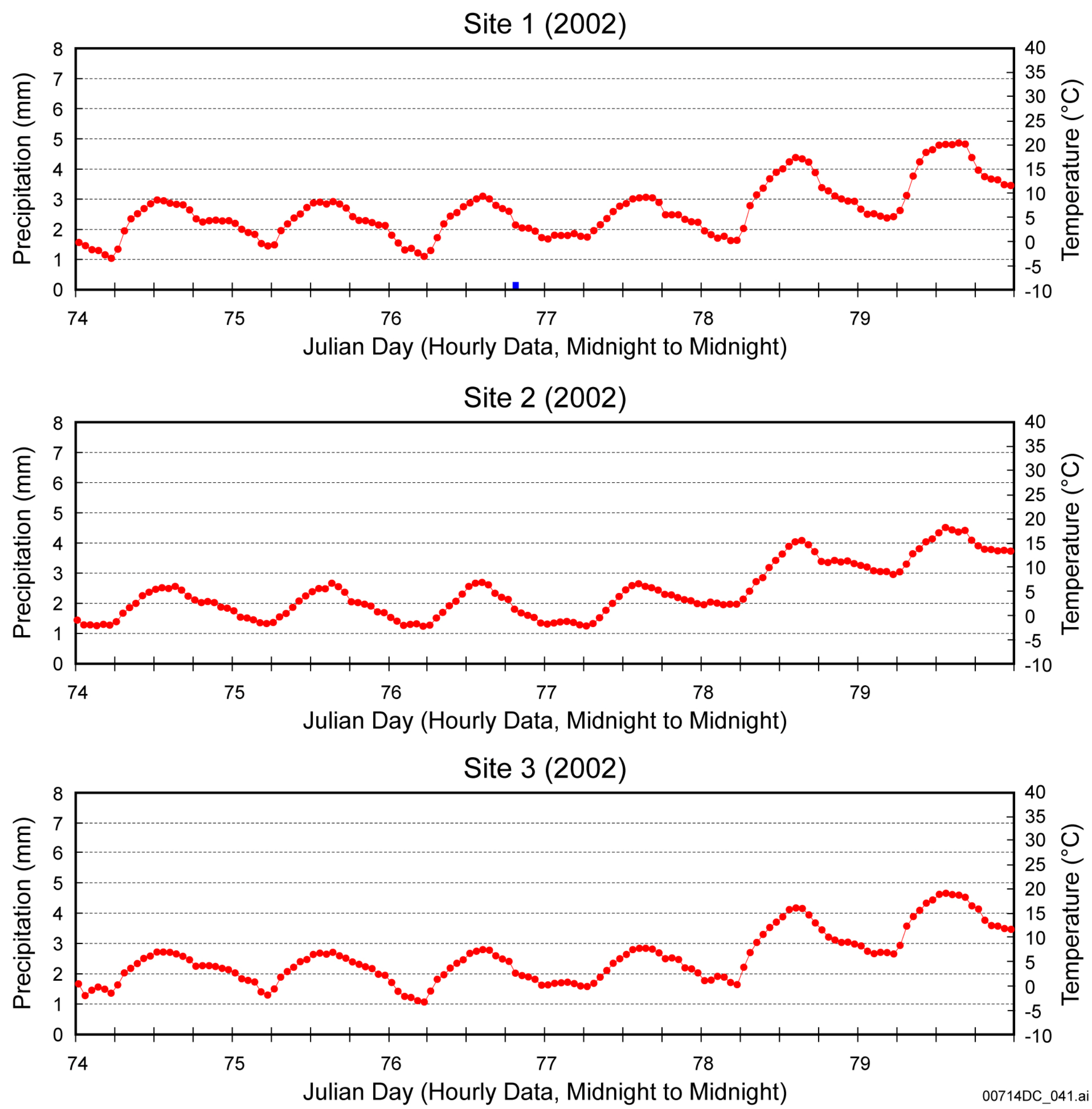
Figure D-12b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 330 through 335 in 1998



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
A large skew in the temperature plot represents an N/A recorded in the temperature data (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

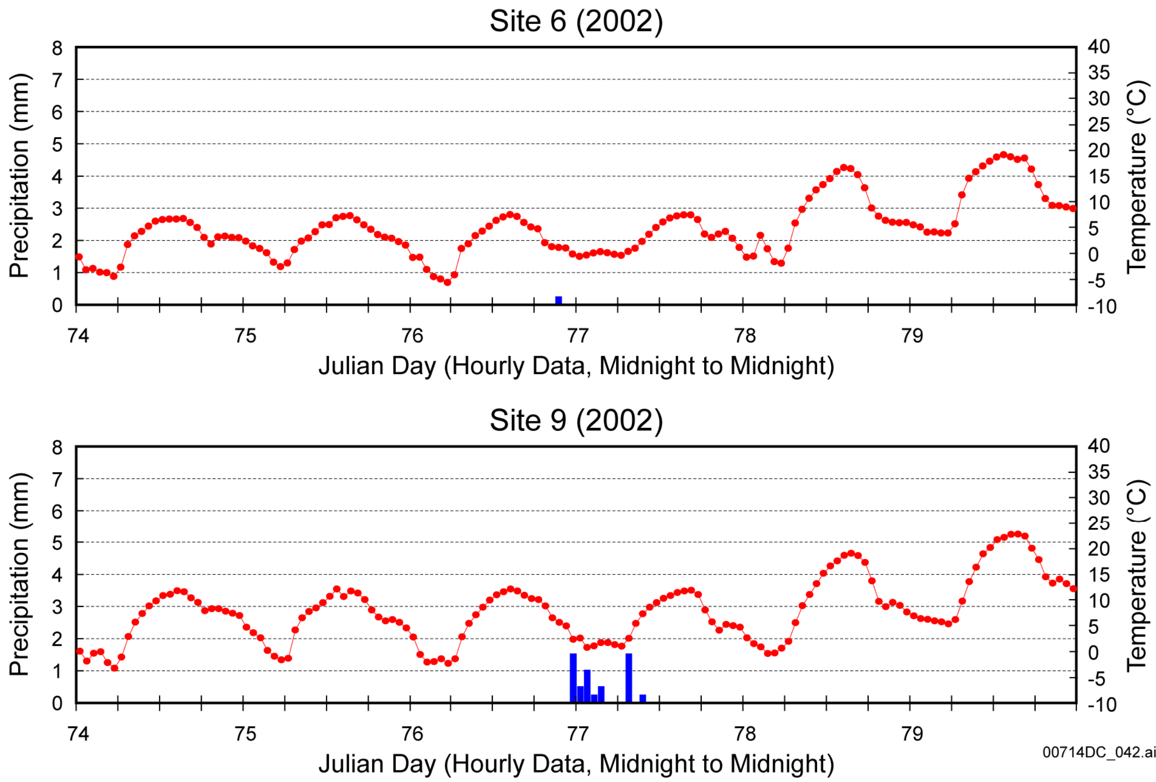
Figure D-12c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 330 through 335 in 1998



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

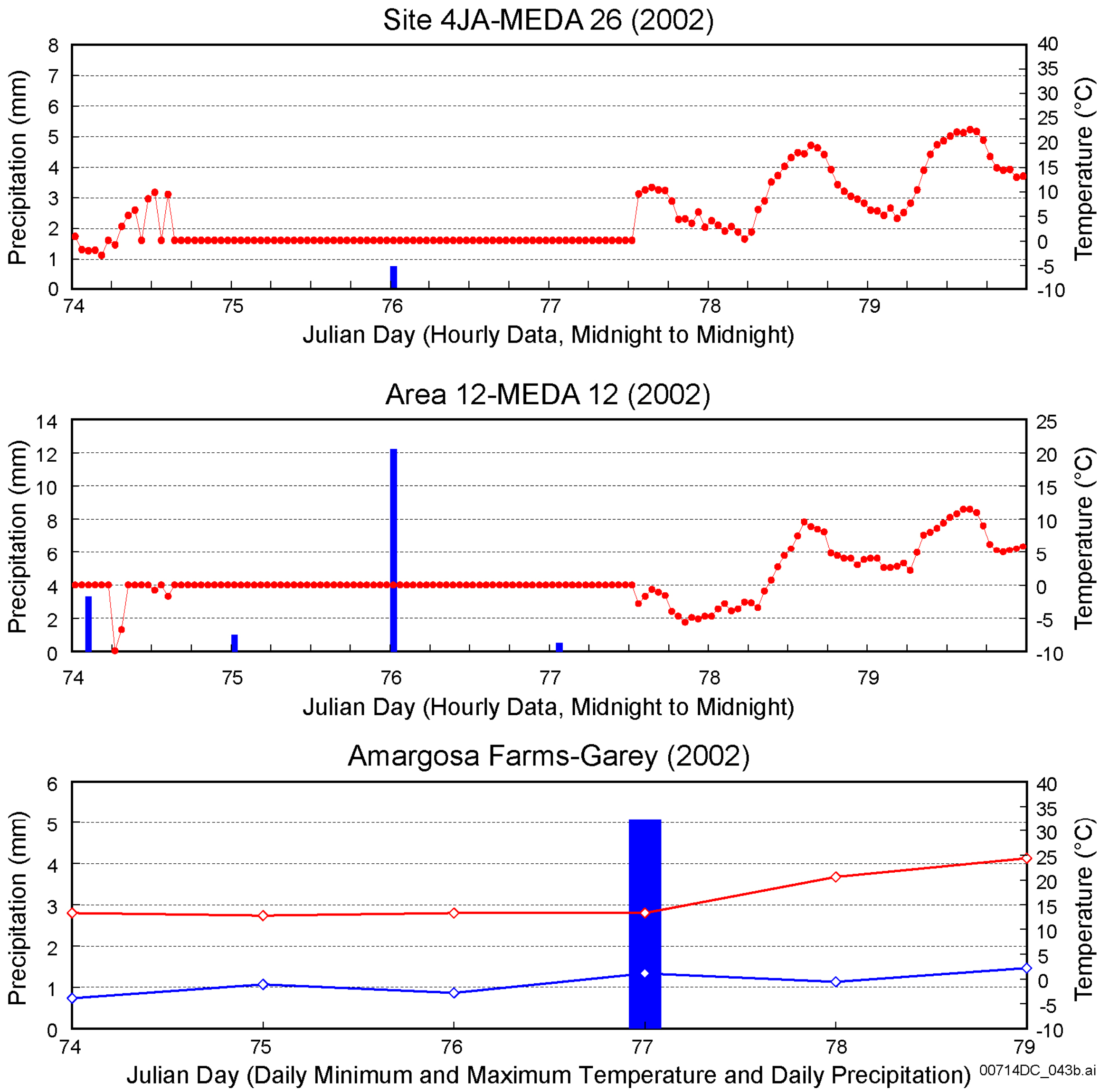
Figure D-13a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 74 through 79 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

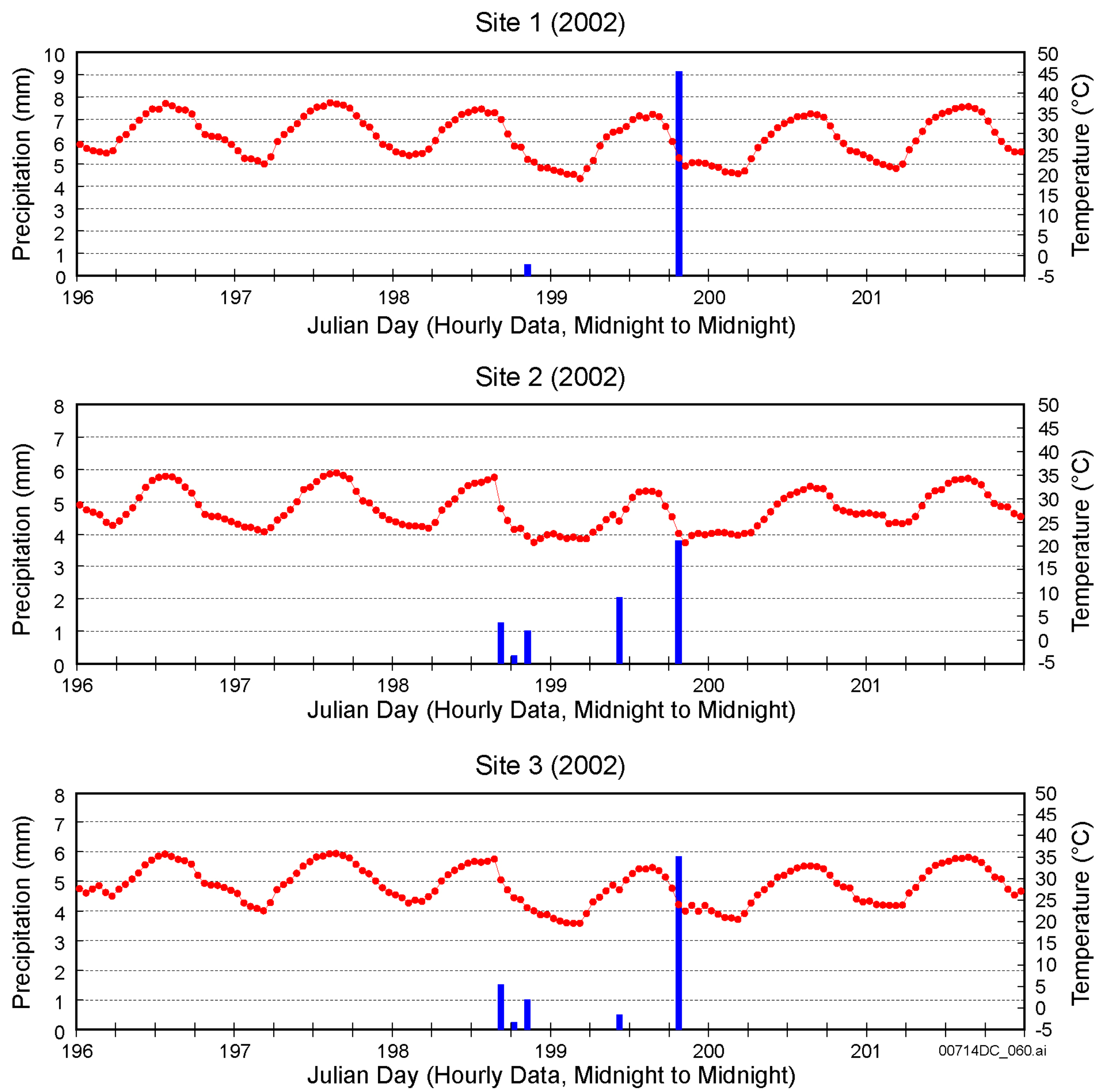
Figure D-13b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 74 through 79 in 2002



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
Temperatures plotted as zero represent N/A from the temperature data (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

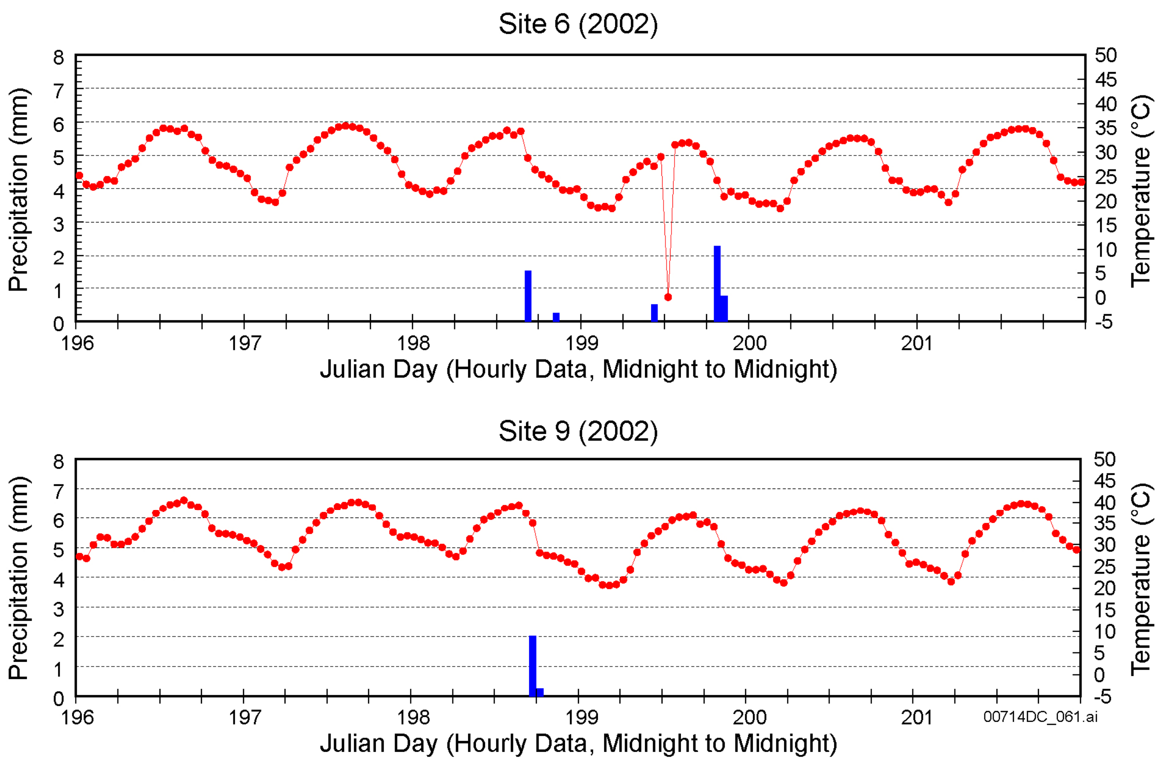
Figure D-13c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 74 through 79 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

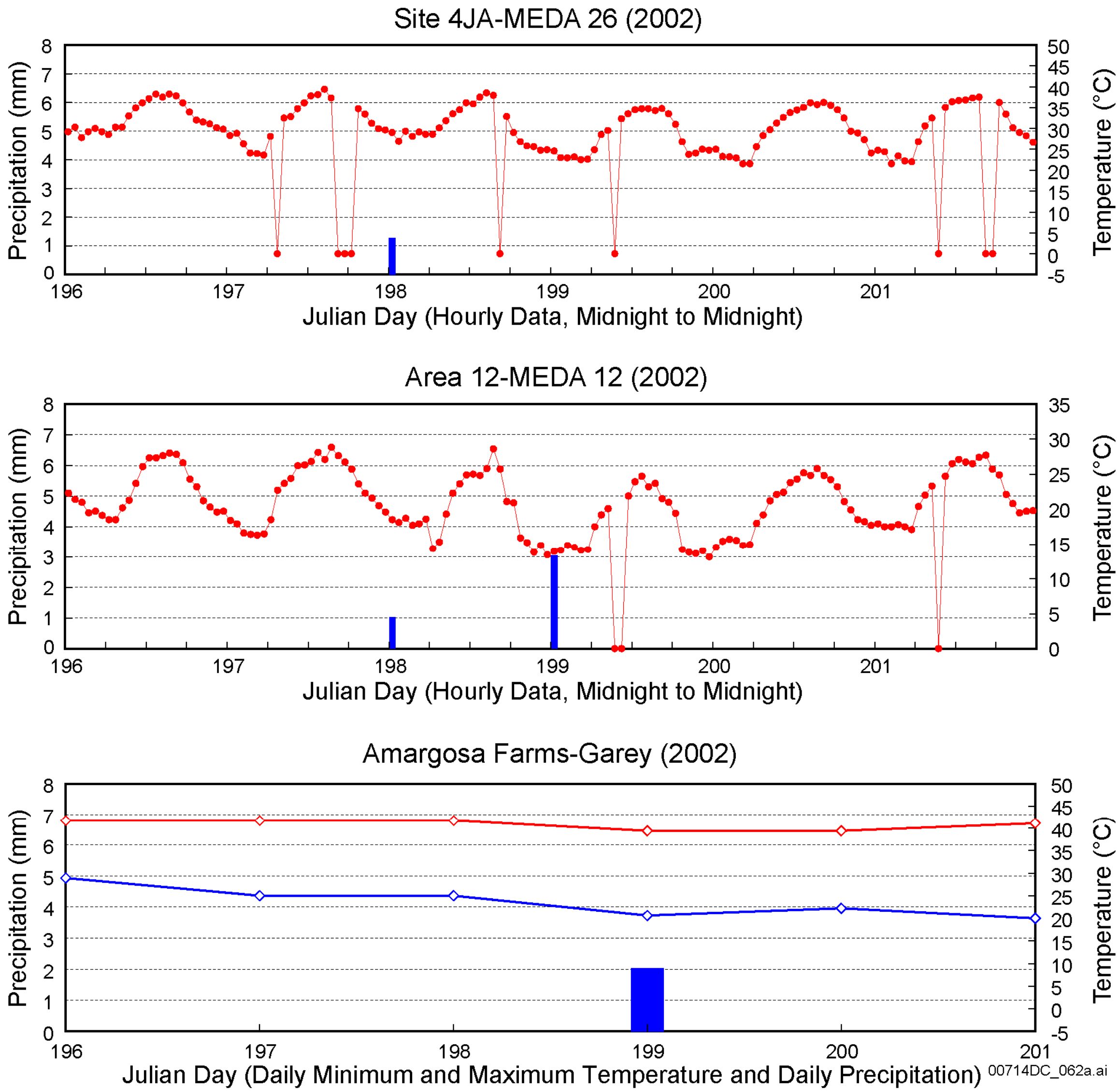
Figure D-14a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 196 through 201 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. A skew in the temperature plot represents an N/A data record (missing data). Plots may vary in format and range.

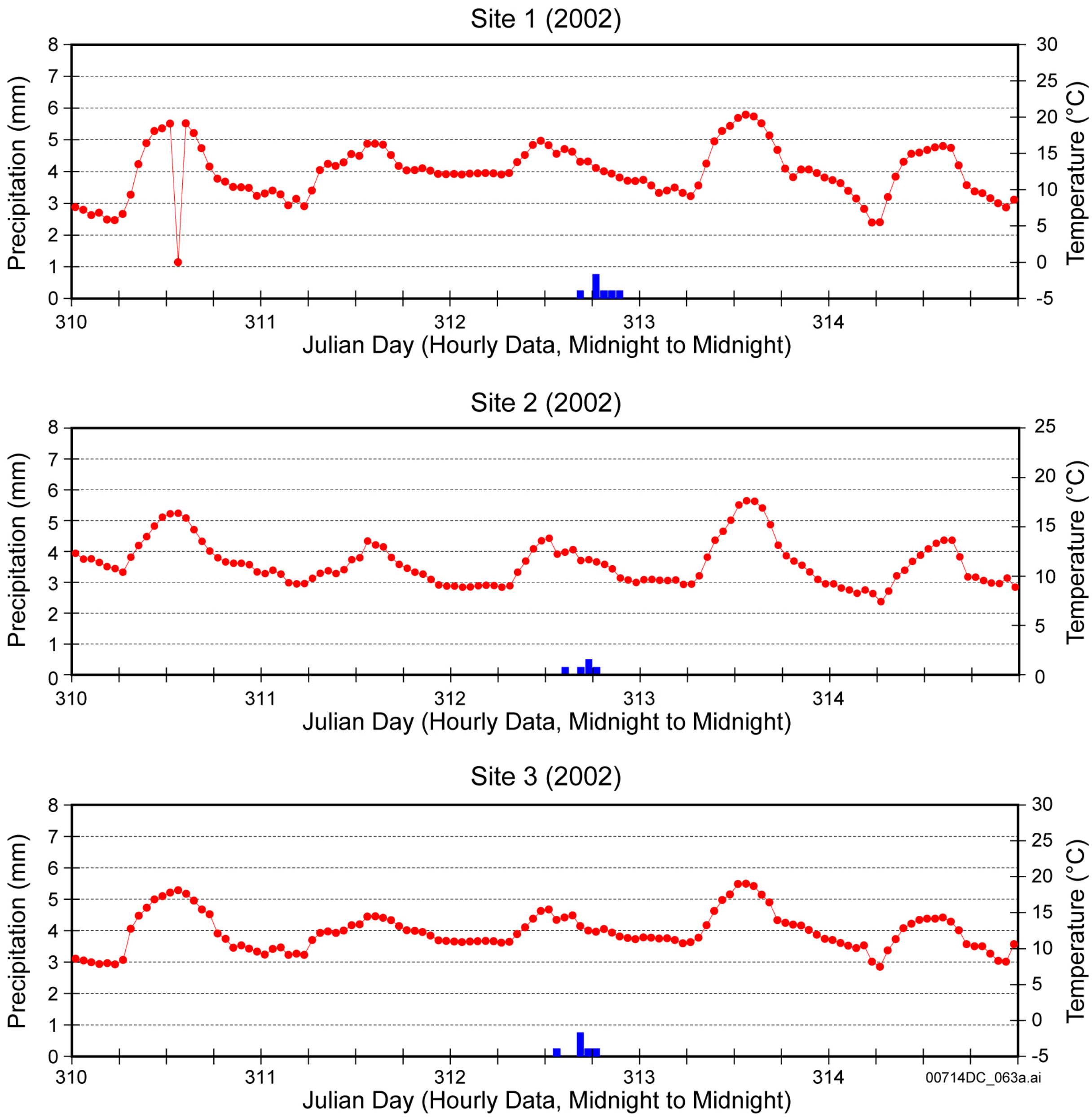
Figure D-14b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 196 through 201 in 2002



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
A skew to zero in the temperature data represents an N/A data record (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

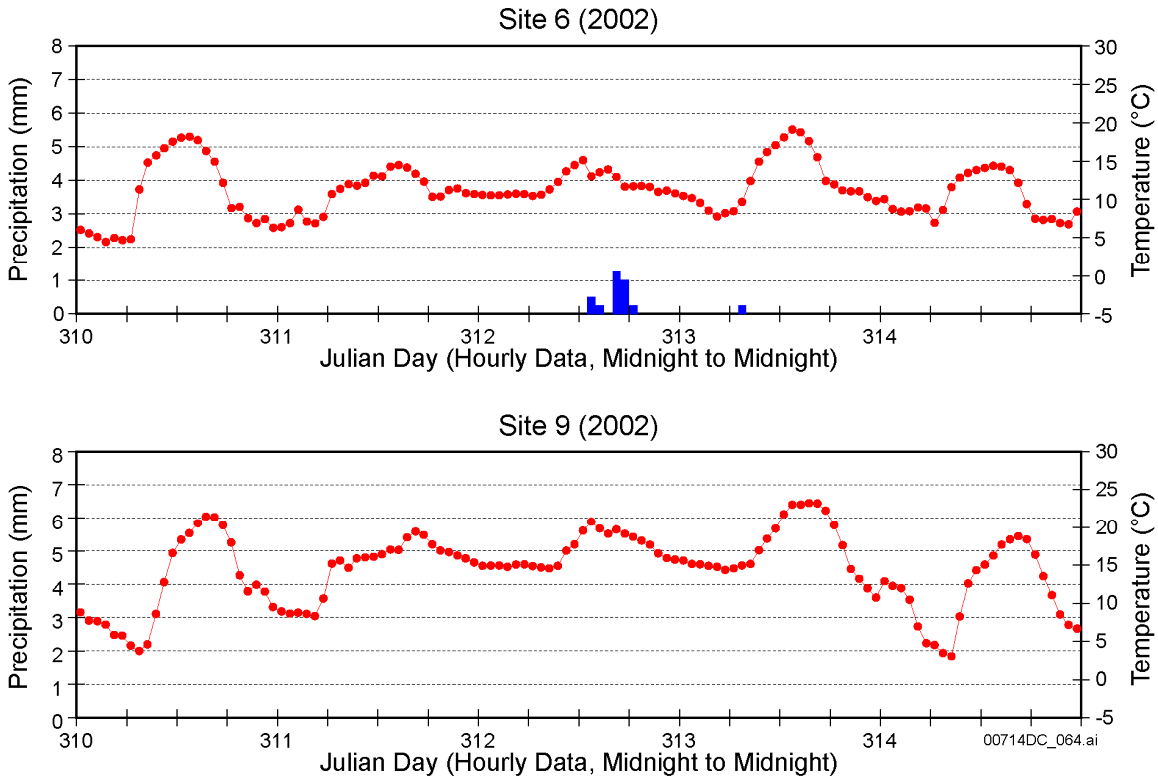
Figure D-14c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 196 through 201 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. A skew to zero in the temperature data represents an N/A data record (missing data). Plots may vary in format and range.

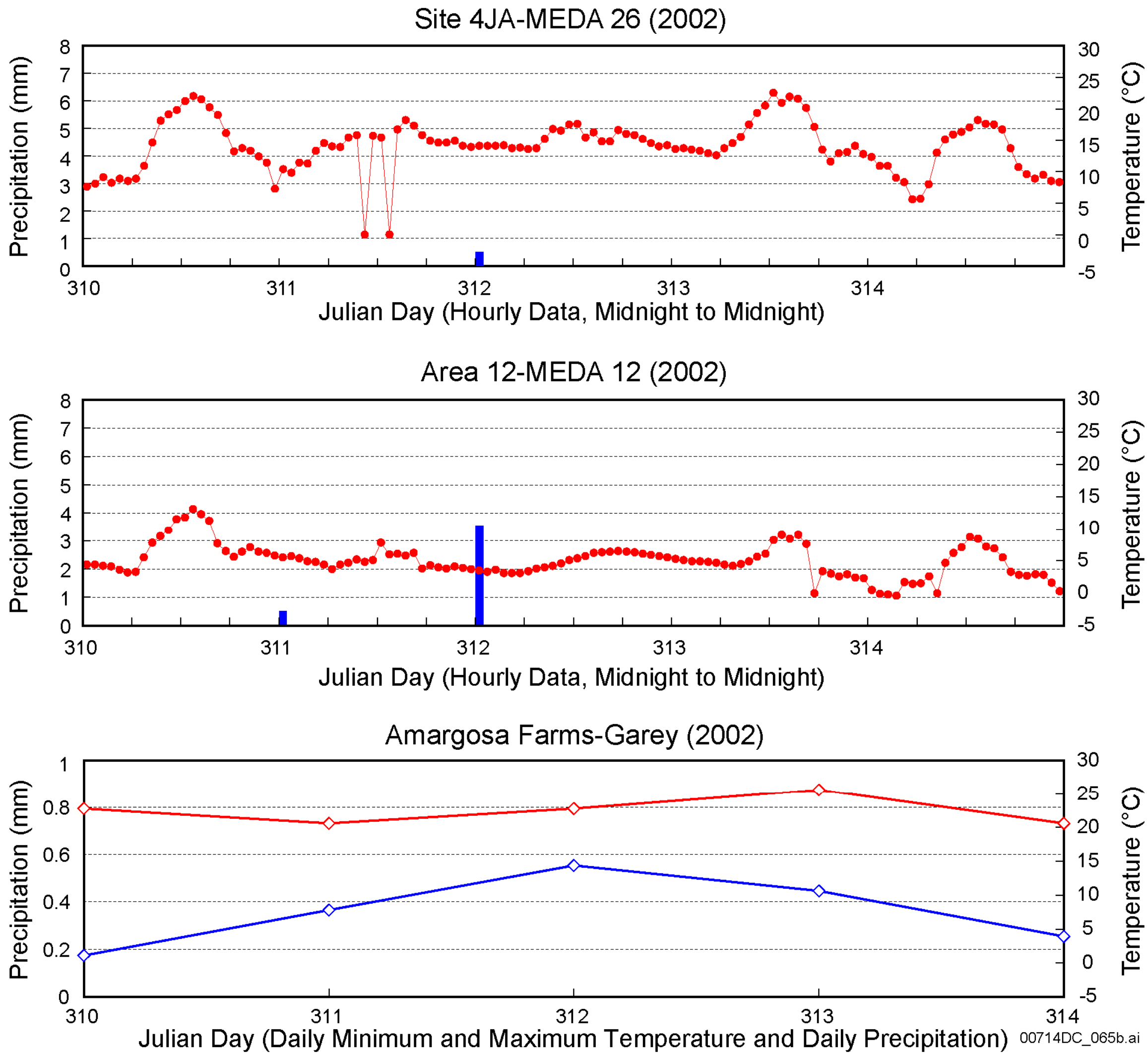
Figure D-15a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 310 through 314 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

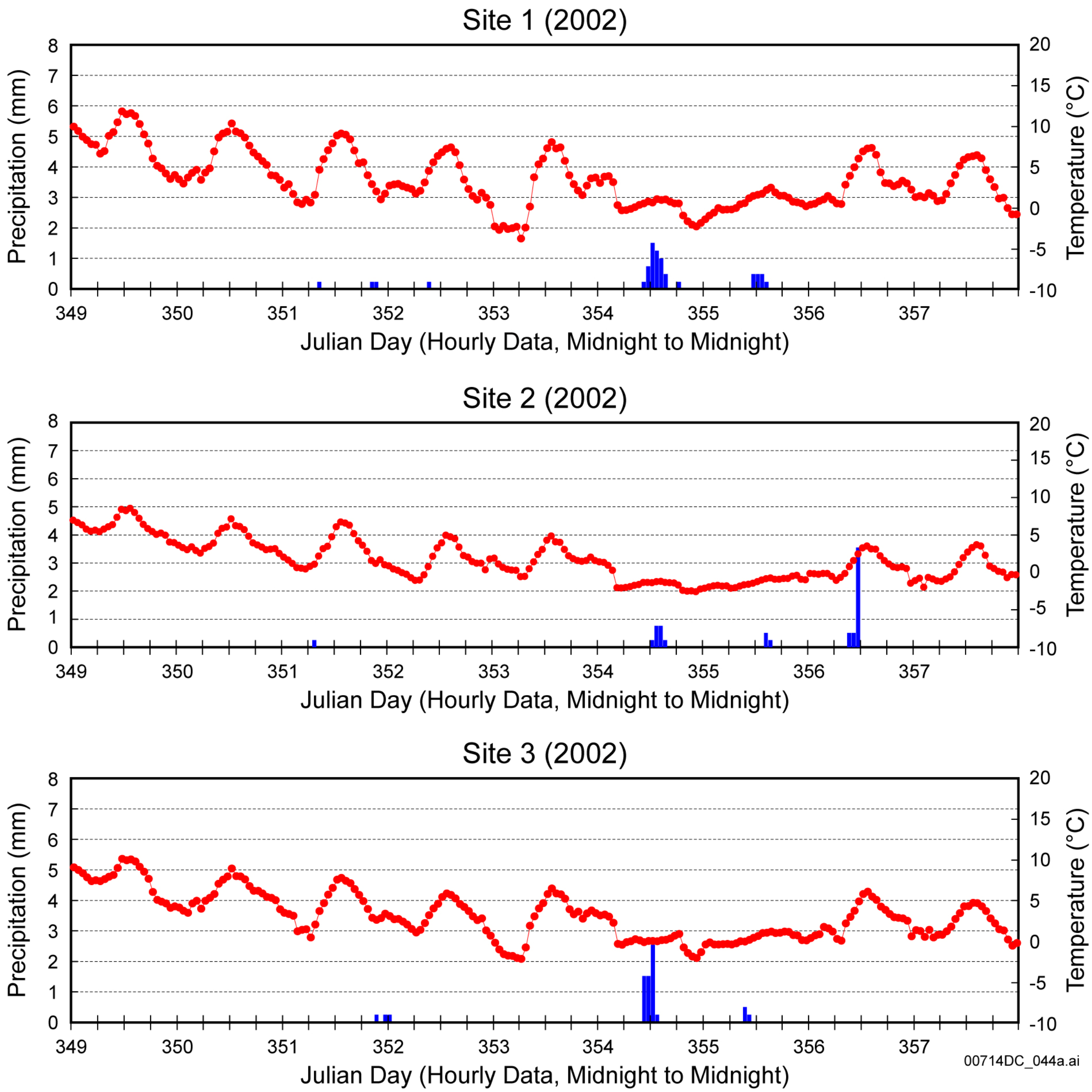
Figure D-15b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 310 through 314 in 2002



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
A skew to zero in the temperature plot represents an N/A data record (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

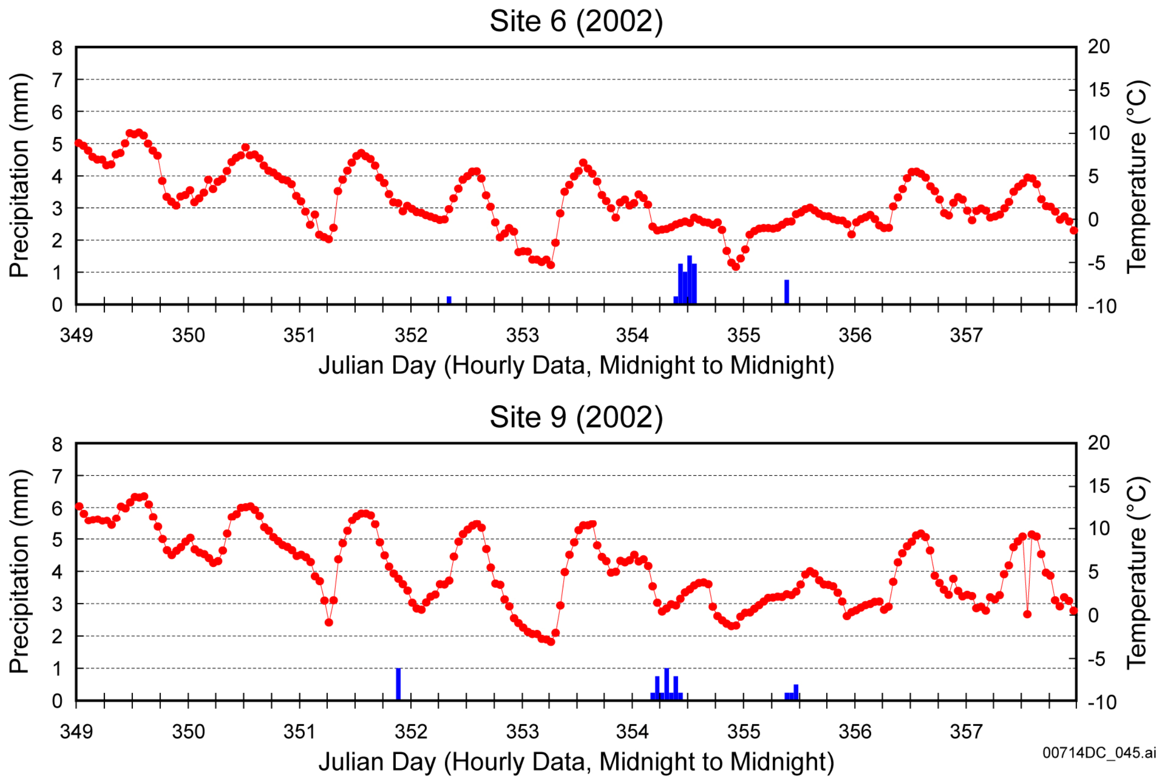
Figure D-15c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 310 through 314 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. Plots may vary in format and range.

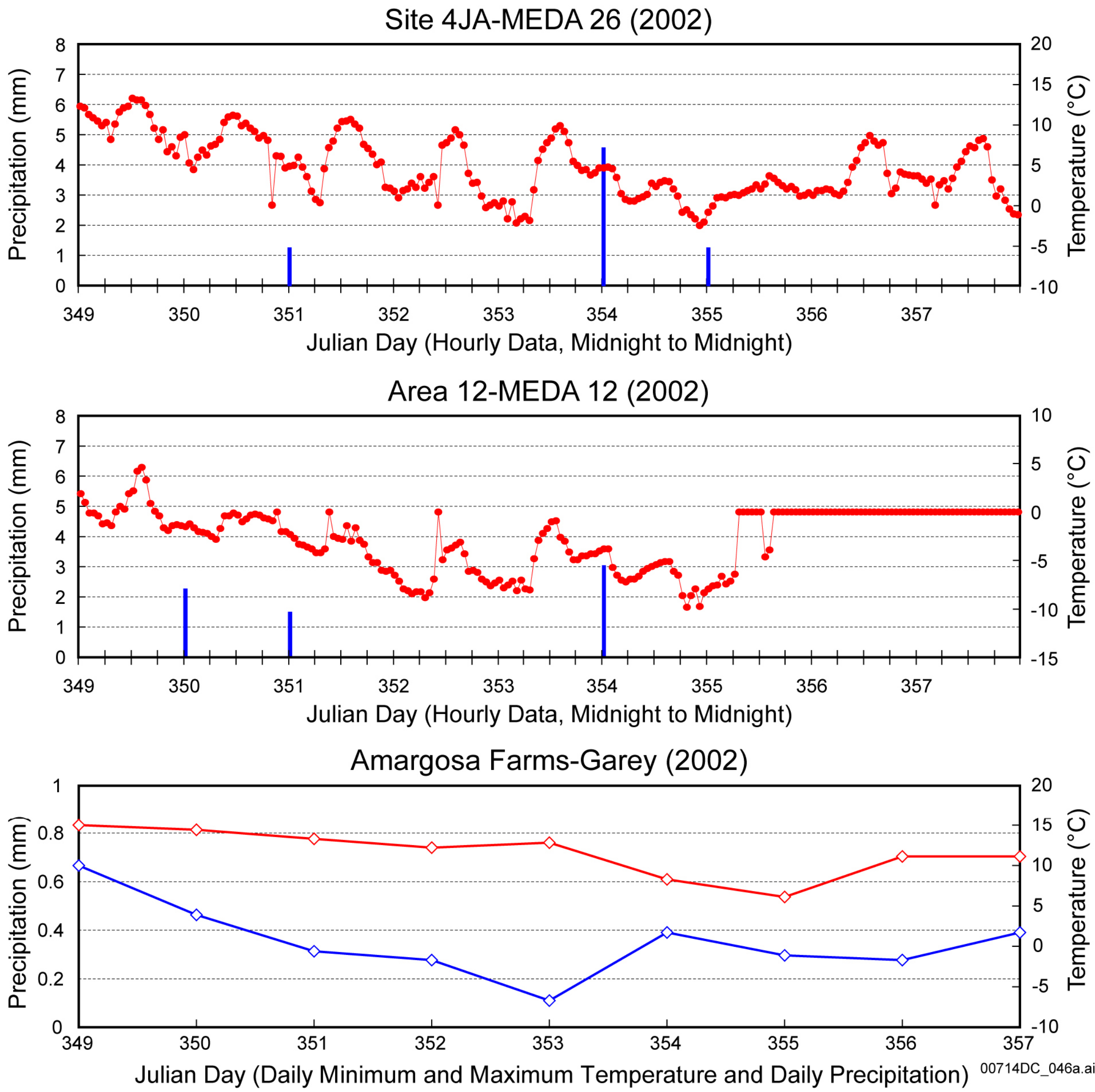
Figure D-16a. Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 for Julian Days 349 through 357 in 2002



Source: See Appendix F.

NOTE: Temperature and precipitation are plotted as hourly data. A skew to zero in the temperature plot represents an N/A data record (missing data). Plots may vary in format and range.

Figure D-16b. Temperature and Precipitation for YM Site 6 and YM Site 9 for Julian Days 349 through 357 in 2002



Source: See Appendix F.

NOTES: Temperature is hourly data and precipitation is daily data.
Daily precipitation data are plotted at the first hour of the day.
The zero temperature plateaus represent N/A data records (missing data).
Daily temperature data from MEDA 26 were coupled with precipitation data from site 4JA.
Daily temperature data from MEDA 12 were coupled with precipitation data from Area 12.
Plots may vary in format and range.

Figure D-16c. Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey for Julian Days 349 through 357 in 2002

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APPENDIX E

JUSTIFICATION FOR INCLUSION OF DAYS WITH FEWER THAN 24 HOURS OF HOURLY DATA

The temperature data for this analysis are used to develop inputs that represent the present-day and future climate at Yucca Mountain for use in infiltration modeling. Some of the data were recorded hourly. From the hourly measurements, daily-temperature averages, and minimum and maximum values, were calculated. There are some days in the year that do not have a full set of temperature measurements (i.e., 24 one-hour measurements) due to instrumentation or data acquisition errors. Days that were missing six or more hours of temperature data were denoted as having insufficient temperature records needed to derive daily-temperature averages, and minimum and maximum values, and were eliminated from the data set. For days missing one to five hours of hourly data, daily average and minimum and maximum values were calculated; this appendix justifies the calculation of these values.

This analysis focuses only on the 11 years of temperature data recorded at the Yucca Mountain stations (output DTN: SN0608WEATHER1.005). The year 1993 has a mix of temperature data measured at 10 m agl and 2 m agl. This year was excluded from this comparison to optimize the consistency of data in the comparison. The topic of the two temperature measurement heights is addressed in Assumption 1 in Section 5.

This appendix shows that daily minimum and maximum temperature values, and temperature averages that are derived using from 19 to 23 of the 24 hourly-temperature readings, are only a small subset of the full data set used in the analysis. Furthermore, the analysis shows that any differences between a calculated average that uses 24 hourly measurements and an average that uses 19 to 23 of the 24-hour measurements are insignificant.

Using the temperature values recorded with the 2 m agl sensor, 4,018 days (1994 to 2004) are used as inputs in deriving predicted temperature values for the infiltration model. Table E-1 lists the number of days, over an 11-year period, when fewer than the full complement of daily (24 hourly) measurements were used to determine daily minimum and maximum temperature and a calculated daily average temperature.

The information provided in Table E-1 indicates that for those days in which there are missing hourly temperature data, over 50% of the total had only one or two hours of temperature data missing from the records. Those days for which three to five hours of data are missing constitute a small subset. The last column in Table E-1 lists the percentage of days for which hourly temperature values are missing. The data in Table E-1 shows that, of the total number of days used as input, less than 3% had fewer than 24 hourly temperatures recorded. Of those days with fewer than 24 hourly records, most were missing only one or two hours of data.

Because temperature is not always a smooth and linear function, as the number of missing hours increases, the difference between an average temperature calculated with the full 24-hour measurements and one calculated with between one to five of the hourly measurements missing becomes less predictable.

Table E-1. Number of Days, between 1994 through 2004, Where a Minimum, Maximum, and Average Daily Temperature Is Determined Using Fewer Than the Full Set of 24 Hourly-Temperature Measurements for YM Site Stations 1, 2, 3, 6, and 9

Number of Hours, by Site, When Hourly Temperature Data Are Missing	Number of Days in 11-Year Period with Missing Hours and Percent Frequency		Percent Ratio of the Total Number of Days (4,018) to Days Where Calculated Daily Summary Temperature Values Determined with 1 to 5 Hours of Missing Data
Site 1	**Days**	**Cumulative %**	**Percent of Total Days**
1 hour	28	31.82%	<1%
2 hours	21	55.68%	<1%
4 hours	16	73.86%	<0.5%
5 hours	12	87.50%	<0.4%
3 hours	11	100.00%	<0.3%
Site 1 - Total number of days using fewer than 24 one-hour temperature values	*88*		~2%
Site 2	**Days**	**Cumulative %**	**Percent of Total Days**
2 hours	41	41.41%	1%
1 hour	33	74.75%	<1%
3 hours	13	87.88%	<0.3%
5 hours	7	94.95%	<0.2%
4 hours	5	100.00%	<0.2%
Site 2 - Total number of days using fewer than 24 one-hour temperature values	99		~2%
Site 3	**Days**	**Cumulative %**	**Percent of Total Days**
1 hour	27	37.50%	<0.7%
2 hours	25	72.22%	<0.7%
4 hours	10	86.11%	<0.3%
3 hours	7	95.83%	<0.2%
5 hours	3	100.00%	<0.1%
Site 3 - Total number of days using fewer than 24 one-hour temperature values	72		<2%
Site 6	**Days**	**Cumulative %**	**Percent of Total Days**
1 hour	36	50.70%	<0.9%
2 hours	19	77.46%	<0.5%
3 hours	9	90.14%	<0.3%
5 hours	5	97.18%	<0.2%
4 hours	2	100.00%	<0.05%
Site 6 - Total number of days using fewer than 24 one-hour temperature values	71		<2%

Table E-1. Number of Days, between 1994 through 2004, Where a Minimum, Maximum, and Average Daily Temperature Is Determined Using Less Than the Full Set of 24 Hourly-Temperature Measurements for YM Site Stations 1, 2, 3, 6, and 9 (Continued)

Number of Hours, by Site, When Hourly Temperature Data Are Missing	**Number of Days in 11-Year Period with Missing Hours and Percent Frequency**		**Percent Ratio of the Total Number of Days (4,018) to Days Where Calculated Daily Summary Temperature Values Determined with 1 to 5 Hours of Missing Data**
Site 9	**Days**	**Cumulative %**	**Percent of Total Days**
1 hour	35	41.67%	<1%
2 hours	32	79.76%	<1%
3 hours	11	92.86%	<0.3%
4 hours	5	98.81%	<0.2%
5 hours	1	100.00%	<0.05%
Site 9 - Total number of days using fewer than 24 one-hour temperature values	84		~2%

Source: Appendix F

An assessment of the effects of eliminating hourly temperature data in determining an average value, when three to five hours of data are missing, is given in the Table E-2. In this table, an average temperature of 10.22°C has been calculated for YM Site 9 on Julian day 324 in 2003 using the full set of 24-hour temperature data. Table E-2 presents cases in which between one and five hours of temperature data were systematically removed in the calculation of average temperature. The hour in which the measured value is omitted progresses from the first through the twenty-fourth hour of the day, and the number of hours eliminated, in the daily average temperature calculation, progressively increases from one to five hours. For example, the average daily temperature indicated in the *Start-Hour* (column 3), and the *Number of Missing Hours* (row 4), was determined by omitting the four hours of temperature measurements starting at 3:00 AM (that is, temperature recorded at 3:00, 4:00, 5:00, and 6:00 AM).

Table E-2. Calculated Average Temperature Derived by Eliminating One to Five Hours of Hourly Data

Comparison between Average Daily Temperature Calculated Using All 24 Hourly Values (10.22°C) and Daily Average Temperature Calculated Omitting One to Five Hours of Temperature Data for Site 9, Julian Day 324 of 2003													
Number of Missing Hours	**Hour Where Recorded Temperature Is Eliminated in the Average Calculation ->**	**The 'Start' Hour During the Day for Which Data Are Missing**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	Calculated Average ->	10.34	10.50	10.51	10.56	10.56	10.45	10.44	10.34	10.25	10.14	10.04	9.97
	Degree Difference ->	–0.12	–0.28	–0.29	–0.34	–0.34	–0.23	–0.22	–0.12	–0.03	0.08	0.18	0.25
2	Calculated Average ->	10.50	10.55	10.61	10.66	10.68	10.69	10.58	10.38	10.17	9.95	9.77	9.66
	Degree Difference ->	–0.28	–0.33	–0.39	–0.44	–0.46	–0.47	–0.36	–0.16	0.05	0.27	0.45	0.56
3	Calculated Average ->	10.69	10.79	10.86	10.93	10.94	10.84	10.62	10.30	9.96	9.66	9.44	9.32
	Degree Difference ->	–0.47	–0.57	–0.64	–0.71	–0.72	–0.62	–0.40	–0.08	0.26	0.56	0.78	0.90
4	Calculated Average ->	10.95	11.06	11.15	11.22	11.11	10.90	10.55	10.09	9.67	9.30	9.07	8.94
	Degree Difference ->	–0.73	–0.84	–0.93	–1.00	–0.89	–0.68	–0.33	0.13	0.55	0.92	1.15	1.28
5	Calculated Average ->	11.24	11.38	11.46	11.41	11.19	10.84	10.34	9.78	9.29	8.91	8.65	8.53
	Degree Difference ->	–1.02	–1.16	–1.24	–1.19	–0.97	–0.62	–0.12	0.44	0.93	1.31	1.57	1.69
Number of Missing Hours	**Hour Where Recorded Temperature Is Eliminated in the Average Calculation ->**	**Hour During the Day for Which Data Are Missing**											
		13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	Calculated Average ->	9.94	9.94	9.93	9.94	10.04	10.21	10.26	10.23	10.27	10.30	10.33	10.38
	Degree Difference ->	0.28	0.28	0.29	0.28	0.18	0.01	–0.04	–0.01	–0.05	–0.08	–0.11	–0.16
2	Calculated Average ->	9.63	9.62	9.62	9.74	10.02	10.25	10.26	10.28	10.36	10.42	10.50	10.50
	Degree Difference ->	0.59	0.60	0.60	0.48	0.20	–0.03	–0.04	–0.06	–0.14	–0.20	–0.28	–0.28
3	Calculated Average ->	9.27	9.28	9.39	9.70	10.05	10.25	10.32	10.37	10.48	10.60	10.63	10.68
	Degree Difference ->	0.95	0.94	0.83	0.52	0.17	–0.03	–0.10	–0.15	–0.26	–0.38	–0.41	–0.46
4	Calculated Average ->	8.90	9.02	9.34	9.72	10.04	10.31	10.41	10.50	10.67	10.74	10.83	10.89
	Degree Difference ->	1.32	1.20	0.88	0.50	0.18	–0.09	–0.19	–0.28	–0.45	–0.52	–0.61	–0.67
5	Calculated Average ->	8.61	8.95	9.33	9.69	10.09	10.41	10.55	10.69	10.83	10.95	11.05	11.17
	Degree Difference ->	1.61	1.27	0.89	0.53	0.13	–0.19	–0.33	–0.47	–0.61	–0.73	–0.83	–0.95

Source: Appendix F

In the same column (*Number of Missing Hours*, row 3), one row down, a daily temperature average is calculated where five hours of temperature data have been omitted starting at 3:00 AM (denoted as '3' in the table). The missing hours are 3:00, 4:00, 5:00, 6:00, and 7:00 AM. The difference between the average calculated using the full set of 24-hour measurements, and that calculated with less than the full set is listed in the *Degree Difference* row. The table shows that when five hours of temperature data are eliminated, the calculated average temperature varies, at most, by approximately 1.5°C. For the majority of calculated averages, the difference between the value determined using all 24 hourly measurements and that using 23 to 19 hours of data is less than 1°C.

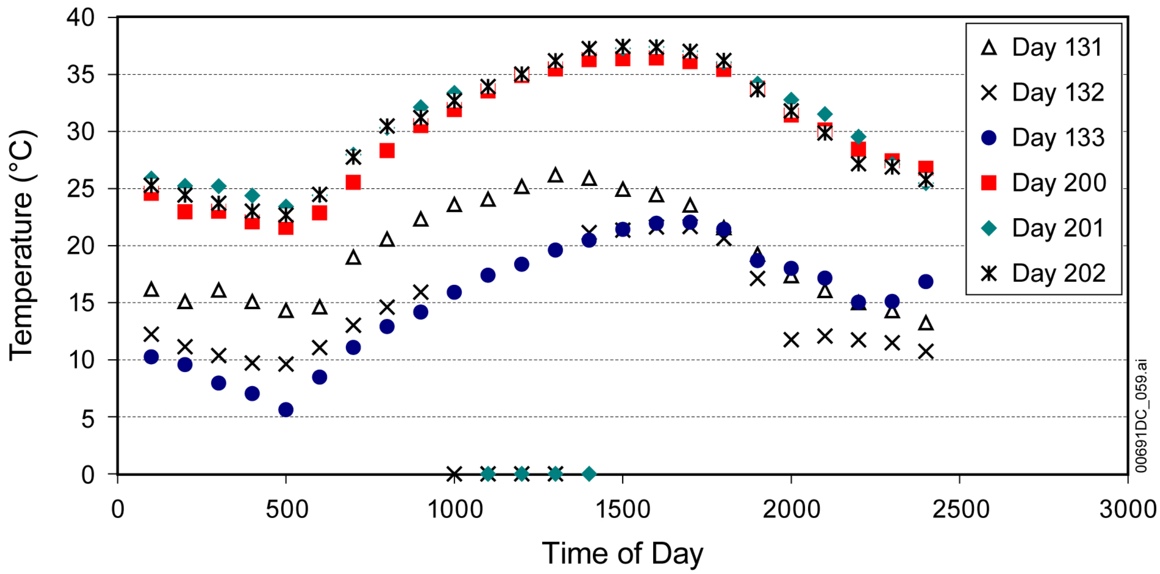
There is little difference between the calculated average daily temperature obtained by using 19 to 23 hours of temperature data, and the average obtained by using the full complement of hourly data. Table E-2 indicates that using only 22 or 23 hours of temperature data has little impact on determining average temperature values. The table also illustrates that, as the number of hours are removed in deriving an average temperature, the temperature difference varies, but the variation is dependent on the time of day during which the "missing" hours occur, and the number of hours. When only one or two hours of data are removed, only small differences are seen in the resulting temperature average.

Furthermore, in desert climates, due to the low number of precipitation events and minimal cloud-cover, hourly temperatures vary little between consecutive days (i.e., from day to day, the hourly temperature cycle follows very similar trends in their temperature peaks, extreme lows, plateaus, and declines). Incremental increases or decreases in hourly temperature values tend to be for adjacent days as the days transition from one season to another. At the Yucca Mountain site stations discussed in this report, hourly temperatures recorded on a particular day will usually be similar to those values recorded at the same time on the preceding and following days. By comparing the average calculated temperature to the calculated average values of "adjacent" days for which there are 24 hourly measurements, the error introduced by using fewer than 24 hourly measurements can be qualitatively determined.

Adjacent days can be used as analogues to assess the most likely temperature difference between a temperature average calculated with hourly data missing, and an average calculated with 24 hourly measurements. For example, compare a calculated average temperature value for adjacent days that lack no hourly data to a day for which hourly data are missing; knowing that adjacent days most likely have similar temperature cycles, one can qualitatively assess the possible error in finding the mean, maximum, or minimum for the missing-data day.

For illustrative purposes, an actual day, for which a temperature average is calculated using fewer than 24 hourly-temperature measurements, is reviewed. This exercise is illustrated in plots of 24-hour temperature profiles, for six days recorded at YM Site 1 during 2004. For this exercise, average temperature values are determined for the day before and the day after those days for which hourly temperature data are missing.

Using the 24 hourly values, an average temperature value is calculated for the "adjacent" days; this average temperature is then compared to an "average" temperature calculated after removing the same hours of temperature data that are missing for the "target day."



Source: Appendix F.

Figure E-1. Hourly Temperature Data (in military time) at YM Site 1 (Julian days 131 through 133 and 200 through 202, Year 2004)

In Figure E-1, Julian days 200 and 202 have a complete set of hourly temperature data. These are plotted with Julian day 201, for which four hours of temperature data are missing. It is seen that the temperature curves of Julian days 200 and 202 fall within 1°C or 2°C of each other (this is the time of year during which temperature values tend to be highest, and vary little from day to day).

The temperature cycles for Julian days 131 and 133 are also plotted on Figure E-1. These days are separated by Julian day 132, for which four hours of temperature values are missing. These days occur in the early spring and, as spring storms move in, the temperature cycle from day-to-day tends to fluctuate. As Figure E-1 illustrates, however, the 24 hourly-temperature values of the preceding and following days follow a similar cycle, and hourly temperatures for Julian day 133 differ by less than 5°C for most of the temperature cycle.

An average temperature is calculated for Julian days 131 and 133 with, and without, the (same) hours of temperature data that are missing for Julian day 132. Given the similarity between the three days, the average temperature calculated for Julian day 130 was probably off by 0.5°C to 1.5°C.

Table E-3. Hourly Temperature (°C) Recorded at YM Site 1 on Julian Days 131 and 133 of 2004, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values

Day 131			Day 133		
Hour	**Hourly Temperature**	**24 Hourly Temperature with Missing[a] Values**	**Hour**	**Hourly Temperature**	**24 Hourly Temperature with Missing[a] Values**
1	16.17	16.17	1	10.25	10.25
2	15.09	15.09	2	9.57	9.57
3	16.1	16.1	3	7.96	7.96
4	15.09	15.09	4	7.03	7.03
5	14.32	14.32	5	5.623	5.623
6	14.63	14.63	6	8.48	8.48
7	18.99	18.99	7	11.08	11.08
8	20.57	20.57	8	12.9	12.9
9	22.33	22.33	9	14.18	14.18
10	23.6	N/A	10	15.91	N/A
11	24.07	N/A	11	17.41	N/A
12	25.19	N/A	12	18.37	N/A
13	26.2	N/A	13	19.61	N/A
14	25.9	25.9	14	20.48	20.48
15	24.94	24.94	15	21.42	21.42
16	24.46	24.46	16	21.96	21.96
17	23.54	23.54	17	22.05	22.05
18	21.57	21.57	18	21.44	21.44
19	19.24	19.24	19	18.68	18.68
20	17.37	17.37	20	18.01	18.01
21	16.05	16.05	21	17.15	17.15
22	15	15	22	15.04	15.04
23	14.3	14.3	23	15.11	15.11
24	13.24	13.24	24	16.84	16.84
Mean Daily Temperature	19.50	18.45	**Mean Daily Temperature**	15.27	14.76
Difference	1.05		**Difference**	0.51	

Source: Appendix F.

[a] Meaning "Hours 10 through 13 Omitted."

N/A = not applicable.

Similarly, for Julian day 201, four hours of temperature data were missing. Table E-4 shows that, with five hours of missing temperature data, the average temperature differed by approximately 1°C. It is assumed that this is the approximate error in the average temperature calculated for Julian day 200 with the four hours of data missing.

Table E-4. Hourly Temperature Recorded at YM Site 1 on Julian Days 200 and 202 of 2004, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values

Day 200			Day 203		
Hour	**Hourly Temperature**	**24 Hourly Temperature with Missing[a] Values**	**Hour**	**Hourly Temperature**	**24 Hourly Temperature with Missing[a] Values**
1	24.59	24.59	1	25.28	25.28
2	22.96	22.96	2	24.44	24.44
3	23.01	23.01	3	23.72	23.72
4	22.08	22.08	4	23.02	23.02
5	21.59	21.59	5	22.68	22.68
6	22.86	22.86	6	24.49	24.49
7	25.54	25.54	7	27.76	27.76
8	28.32	28.32	8	30.48	30.48
9	30.51	30.51	9	31.22	31.22
10	31.92	31.92	10	32.7	32.7
11	33.56	N/A	11	33.94	N/A
12	34.9	N/A	12	35.04	N/A
13	35.48	N/A	13	36.19	N/A
14	36.29	N/A	14	37.27	N/A
15	36.37	36.37	15	37.45	37.45
16	36.43	36.43	16	37.38	37.38
17	36.11	36.11	17	37.02	37.02
18	35.44	35.44	18	36.22	36.22
19	33.79	33.79	19	33.66	33.66
20	31.43	31.43	20	31.81	31.81
21	30.13	30.13	21	29.87	29.87
22	28.44	28.44	22	27.18	27.18
23	27.43	27.43	23	26.89	26.89
24	26.78	26.78	24	25.79	25.79
Mean Daily Temperature	29.83	28.79	**Mean Daily Temperature**	30.48	29.45
Difference	-1.05		**Difference**	-1.03	

Source: Appendix F.

[a] Meaning "Hours 11 through 14 Omitted."

N/A = not applicable.

This type of exercise was performed for all days for which fewer than 24 hours of hourly temperature data were available and a daily temperature average was calculated. The results are given in Tables E-5 and E-6.

For example, the first line in Table E-5 indicates Julian day 64, 1994, was missing five hours of temperature data, starting at 9:00 AM (signified by '9' in the table). To determine the likely temperature difference using only 19 hours of data, temperature averages for adjoining days

(Julian days 63 and 65) were determined with their full set of hourly data, and without the same five hours missing from Julian day 64. The difference is less than 1°C for that specific day.

Because daily temperature is non-monotonic, and because it can have spikes and valleys as fronts move through, similar comparison averages for adjoining days were determined for all days for which there were fewer than the full set of 24 hours of daily temperature data, and a temperature average was calculated. Plots of the difference, in degrees Celsius, follow Tables E-5 and E-6.

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Table E-5. Site 1 – Comparison of Daily Average Temperatures (°C) Derived Using 24 Hourly Temperature Values for Each Hour of the Day and Averages Derived Using Fewer Than 24 Hourly Temperature Values

Year	Hours Missing	N/A Day (day for which three to five hours of temperature data are missing)	Start Time of Missing Hours	Compare to Day Prior[a] (with full set of 24 hourly temperature measurements)[a]	Mean Temp Day Prior (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A day)	Degree Difference (°C)	Day After[a] (with full set of 24 hourly temperature measurements)	Mean Temp Day Prior (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A Day)	Degree Difference (°C)
1994	5	Day 64	9	63	14.63	13.64	0.99	65	12.59	11.83	0.8
	5	Day 236	9	235	26.27	25.67	0.60	237	27.87	27.18	0.7
	3	Day 87	12	86[a]	13.48	12.70	0.78	90[a]	16.47	15.63	0.8
	3	Day 126	9	127[a]	13.79	13.46	0.33	128[a]	14.60	14.22	0.4
	3	Day 127	9	126	13.79	13.46	0.33	128	14.60	14.22	—
1995	5	Day 74	9	73	11.78	11.11	0.67	75	14.01	13.10	0.91
	5	Day 136	10	135	11.52	10.80	0.72	137	11.52	10.80	0.72
	5	Day 262	10	261	25.06	23.65	1.41	263	26.85	25.59	1.26
1996	5	Day 46	11	44[a]	14.63	13.15	1.48	47	14.74	13.77	0.97
	4	Day 339	10	338	3.30	2.52	0.78	340	6.85	6.51	0.34
	3	Day 156	13	155	29.64	28.71	0.93	157	30.50	29.57	0.93
1997	4	Day 12	12	11	6.09	4.89	1.20	13	–1.94	–1.92	–0.02
	3	Day 30	10	29	9.90	9.59	0.31	—	—	—	—
	3	Day 137	7	136	25.65	24.74	0.91	138	24.91	24.74	0.18
1998	5	Day 70	10	69	10.47	9.37	1.10	71	12.66	11.35	1.32
	5	Day 259	10	258	25.68	24.27	1.41	260	26.23	24.65	1.58
	5	Day 342	10	341	0.61	–0.25	0.86	343	2.80	2.11	0.69
	3	Day 22	14	21	4.03	3.34	0.69	23	8.00	7.22	0.78
	3	Day 134	9	133	5.94	5.97	–0.03	135	12.69	12.53	0.17
1999	4	Day 48	11	47	9.18	7.93	1.25	49	10.23	9.16	1.07
	4	Day 139	10	138	20.96	20.03	0.92	140	21.29	20.29	1.00
	4	Day 327	12	326	3.73	2.74	0.99	328	5.83	4.59	1.23
	3	Day 313	10	312	12.36	11.93	0.43	314	12.83	12.18	0.65
2000	5	Day 311	11	310	12.10	10.84	1.26	312	7.00	5.91	—
	4	Day 264	10	263	29.49	28.79	0.70	265	25.47	24.66	0.81
	3	Day 130	10	129	19.91	19.52	0.39	131	18.82	17.99	0.83
2001	4	Day 311	13	310	16.03	14.91	1.12	312	14.97	14.14	0.83
	3	Day 163	9	162	26.57	26.08	0.49	164	19.88	19.97	–0.09

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Table E-5. Site 1 – Comparison of Daily Average Temperatures (°C) Derived Using 24 Hourly Temperature Values for Each Hour of the Day and Averages Derived using Fewer than 24 Hourly-Temperature Values (Continued)

Year	Hours Missing	N/A Day (day for which three to five hours of temperature data are missing)	Start Time of Missing Hours	Compare to Day Prior[a] (with full set of 24 hourly temperature measurements)[a]	Mean Temp Day Prior (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A day)	Degree Difference (°C)	Day After[a] (with full set of 24 hourly temperature measurements)	Mean Temp Day Prior (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A Day)	Degree Difference (°C)
2002	5	Day 43	12	42	7.76	5.73	2.03	44	9.66	8.57	1.09
	4	Day 135	9	134	23.86	23.13	0.73	136	23.67	22.93	0.74
	4	Day 238	9	237	26.68	25.99	0.69	239	27.08	26.45	0.64
	4	Day 318	11	317	12.40	11.36	1.04	319	10.79	9.62	1.17
2003	4	Day 50	11	49	9.34	8.49	0.85	51	9.29	8.54	0.75
	4	Day 148	8	147	29.53	28.90	0.63	149	31.30	30.85	0.45
	4	Day 217	10	216	27.94	26.63	1.31	218	25.76	24.51	1.25
	4	Day 323[a]	11	321	8.41	7.61	0.80	324	10.26	9.32	0.94
2004	4	Day 55	10	54[a]	5.08	4.84	0.24	56	6.68	6.48	0.21
	4	Day 75	11	74	16.78	15.39	1.39	76	16.54	15.62	0.92
	4	Day 132	10	131	19.50	18.45	1.05	133	15.27	14.76	0.51
	4	Day 201	11	200	29.83	28.79	1.04	202	30.48	29.45	1.03

[a] For adjacent days when there are more than five hours of missing data, the adjacent day may be one or two days before or after target day.

Source: Appendix F

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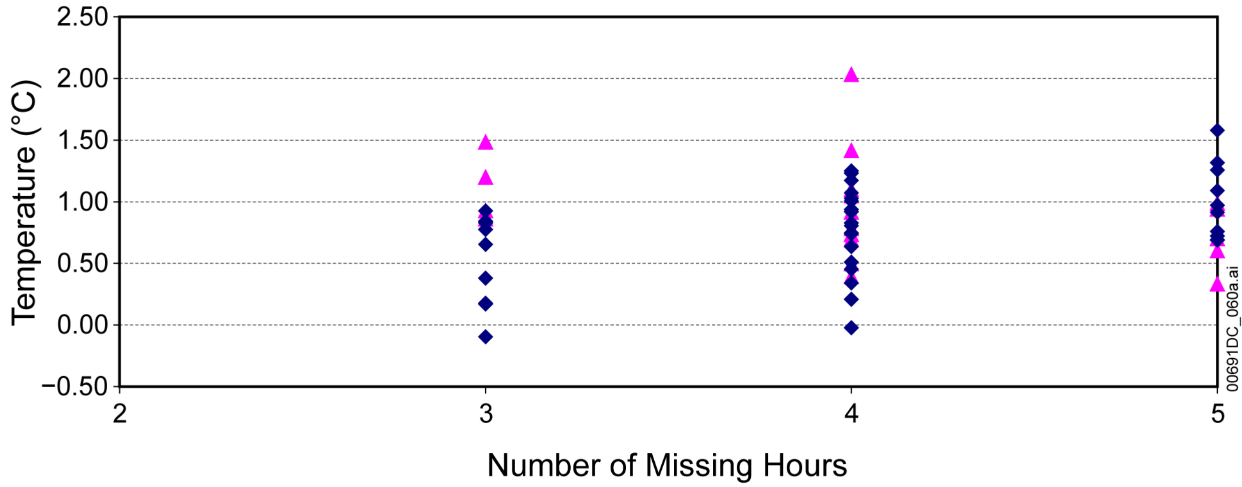


Source: Appendix F

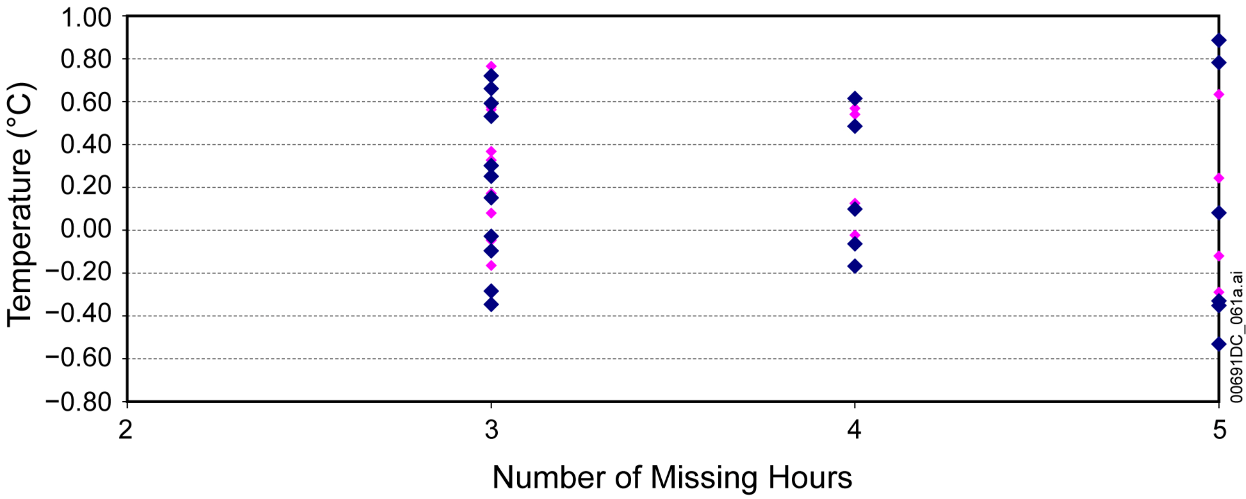
Figure E-2. Site 1 – Temperature Differences for Computed Daily Averages Using 24 One-Hour Temperatures, and Averages Derived Using Fewer Than the Full Set of 24 Hourly Measurements

Table E-6. Site 2 – Comparison of Daily Average Temperature Derived Using 24 Hourly Temperature Values for Each Hour of the Day and Averages Derived Using Less Than the Full 24 Hour Set Values

Year	Hours Missing	N/A Day (day when 3–5 hours missing temp data)	Start Time of Missing Hours	Compare to Day Prior[a] (with no missing hours)	Mean Temp Day Prior (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A Day)	Degree Difference (°C)	Day After[a]	Mean Temp Day After (with no missing hours)	Approximate Mean Temp (derived by eliminating the same missing hours observed on the N/A Day)	Degree Difference (°C)
1994	5	Day 339	3	338	6.40	6.73	–0.33	341[a]	2.97	3.32	–0.35
	4	Day 336	6	335	8.77	8.94	–0.17	337	6.28	6.45	–0.17
1995	5	Day 292	11	291	22.06	21.28	0.78	293	21.22	20.33	0.89
	4	Day 9	2	3[a]	1.16	1.04	0.12	10	3.87	3.93	–0.06
	3	Day 11	10	10	4.88	4.92	–0.05	12	3.87	3.96	–0.10
1996	3	Day 30	14	29	4.82	4.65	0.17	31	4.60	4.45	0.15
	3	Day 205	13	204	31.83	31.17	0.66	206	32.79	32.13	0.66
1997	4	Day 225	10	224	26.08	25.51	0.57	226	27.92	27.43	0.49
1998	5	Day 10	20	9	2.77	2.89	–0.12	11	3.48	3.40	0.08
	5	Day 50	20	49	3.53	3.29	0.24	51	3.25	3.58	–0.33
	5	Day 231	10	230	22.03	21.40	0.63	232	25.23	24.45	0.78
	3	Day 69	13	68	7.96	7.38	0.57	70	12.77	12.24	0.53
	3	Day 46	2	45	4.15	4.07	0.08	47	1.69	1.97	–0.28
1999	3	Day 229	12	228	26.52	25.96	0.56	230	28.93	28.34	0.59
2000	4	Day 236	20	235	26.77	26.23	0.54	237	26.13	25.52	0.61
2001	3	Day 226	14	225	27.78	27.01	0.77	227	29.51	28.79	0.72
2002	3	Day 232	13	231	27.64	27.32	0.32	233	22.35	22.10	0.25
2003	3	Day 251	8	250	24.29	24.46	–0.17	252	19.55	19.90	–0.35
	3	Day 316	22	315	9.92	9.96	–0.04	318[a]	5.20	5.23	–0.03
	3	Day 322	11	321	7.38	7.01	0.37	323	11.96	11.66	0.30
2004	5	Day 363	20	362	4.70	4.99	–0.29	364	3.31	3.84	–0.53
	4	Day 61	21	60	4.32	4.34	–0.02	62	4.33	4.23	0.10

Source: Appendix F.

[a] For adjacent days when there are more than five hours of missing data, the adjacent day may be one or two days before or after target day.

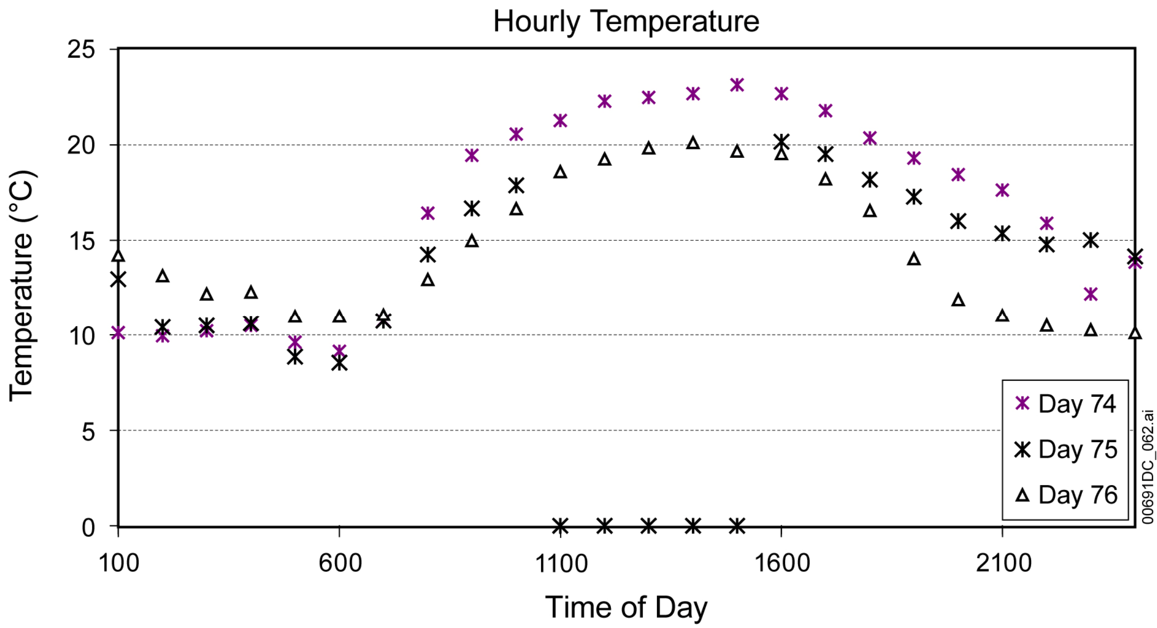


Source: Appendix F.

Figure E-3. Site 2 – Temperature Differences for Computed Daily Averages Using 24 One-Hour Temperatures, and Averages Derived Using Fewer Than the Full Set of 24 Measurements

The justification that using between 19 to 24 hours of hourly temperature data captures daily minimum and maximum temperature values is given below.

An example is given for temperatures recorded at YM Site 6. In 1994, on Julian days 75 and 230, there were five hours for which temperature data was either not recorded or was considered invalid because of instrument problems. Figure E-4 illustrates temperatures curves for Julian days 74, 75, and 76. The peak temperature of 23.15°C for Julian day 74 occurred at 1500 hours; on Julian day 76, a peak temperature of 20.12°C occurred at 1400 hours. For these days, the temperature difference between the peak hour and the temperature recorded during the preceding and following hours varied less than 0.5°C. Temperature peaks appear to occur one hour earlier as the days progress (i.e., the days get longer). From the assessment of temperature peaks and peak times for Julian days 75 and 76, it appears that the peak temperature for Julian day 74 occurred during hour 1500, and may have been slightly higher than the 20.17°C recorded at 1600 hours. It is most likely that the temperature peak for Julian day 74 occurred during hour 1500, and differed by no more than 0.5°C from the temperature recorded at 1600 hours. The temperature curve given in Figure E-4 indicates that the minimum temperature was recorded. Despite the missing hours, a temperature average, and minimum and maximum temperature values, for these days were determined from the source data, and included on the summary worksheets in DTN: SN0608WEATHER1.005.



Source: Appendix F.

Figure E-4. Site 6 Hourly Temperature Data (military time) for Julian Days 74, 75, and 76 (1994)

Table E-7. Hourly Temperature Recorded at YM Site 6 on Julian Days 74 and 76, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values

Hour	Day 74, 1994		Day 76, 1994	
	Hourly Temperature[a]	Hourly Temperature with Missing[b] Values	Hourly Temperature[a]	Hourly Temperature with Missing[b] Values
1	10.11	10.11	14.22	14.22
2	9.95	9.95	13.15	13.15
3	10.21	10.21	12.18	12.18
4	10.49	10.49	12.29	12.29
5	9.62	9.62	10.99	10.99
6	9.14	9.14	11.00	11.00
7	10.76	10.76	11.07	11.07
8	16.43	16.43	12.94	12.94
9	19.46	19.46	14.98	14.98
10	20.56	20.56	16.65	16.65
11	21.27	N/A	18.59	N/A
12	22.28	N/A	19.25	N/A
13	22.49	N/A	19.83	N/A
14	22.69	N/A	20.12	N/A
15	23.15	N/A	19.67	N/A
16	22.69	22.69	19.54	19.54
17	21.79	21.79	18.21	18.21

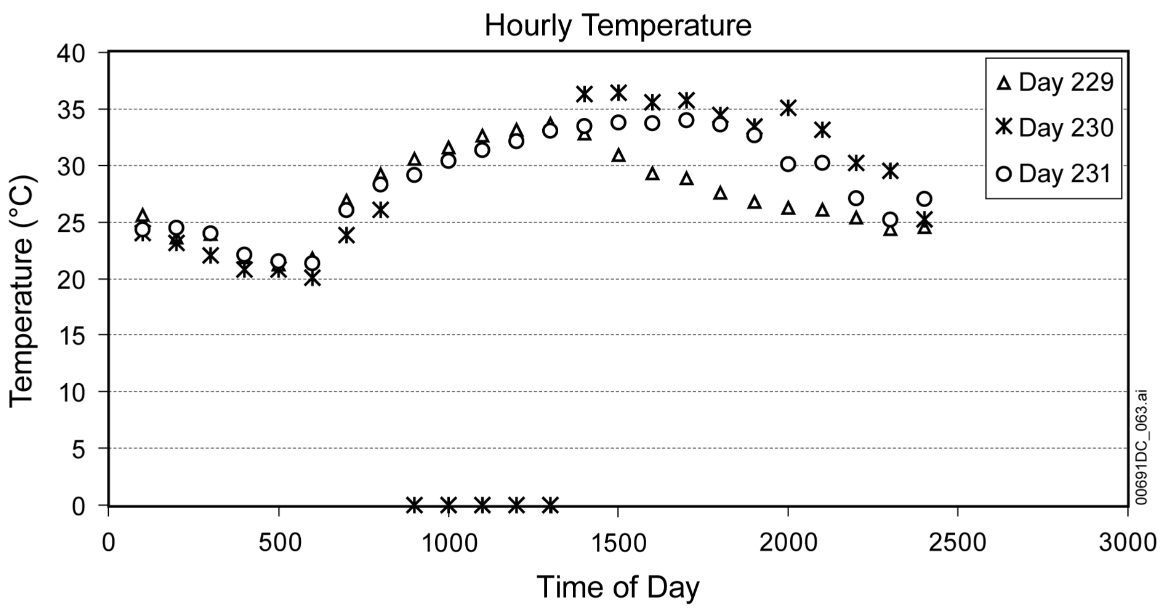
Table E-7. Hourly Temperature Recorded at YM Site 6 on Julian Days 74 and 76, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values (Continued)

Hour	Day 74, 1994		Day 76, 1994	
	Hourly Temperature[a]	Hourly Temperature with Missing[b] Values	Hourly Temperature[a]	Hourly Temperature with Missing[b] Values
18	20.36	20.36	16.55	16.55
19	19.30	19.30	14.04	14.04
20	18.44	18.44	11.88	11.88
21	17.63	17.63	11.05	11.05
22	15.89	15.89	10.51	10.51
23	12.18	12.18	10.26	10.26
24	13.86	13.86	10.11	10.11
Mean Temp	16.70	15.20	14.55	13.24
Degree Difference		-1.49		-1.30

Source: Appendix F

[a] Meaning "Complete Set of 24 Hourly Data Sets."
[b] Meaning "Hours 11 through 14 Omitted."

N/A = not applicable.



Source: Appendix F.

Figure E-5. Site 6 Hourly Temperature Data (military time) for Julian Days 229, 230, and 231 (1994)

On Julian Day 230 in 1994, there were five hours for which temperature data were missing (hours 900 to 1300). Based on temperature peak times for Julian Days 229 and 231, and as illustrated in Figure E-5, it is assumed that the minimum and maximum temperatures for Julian day 230 have been captured. Mean temperature is calculated for Julian day 229 and Julian day

231 with, and without, the same five hours of temperature data that were missing from Julian day 230. The mean temperature derived for Julian day 230 is most likely 1.3°C to 0.6°C lower than what would have been derived if temperature data had been available for the five missing hours.

Table E-8. Hourly Temperature Recorded at YM Site 6 on Julian Days 229 and 231, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values

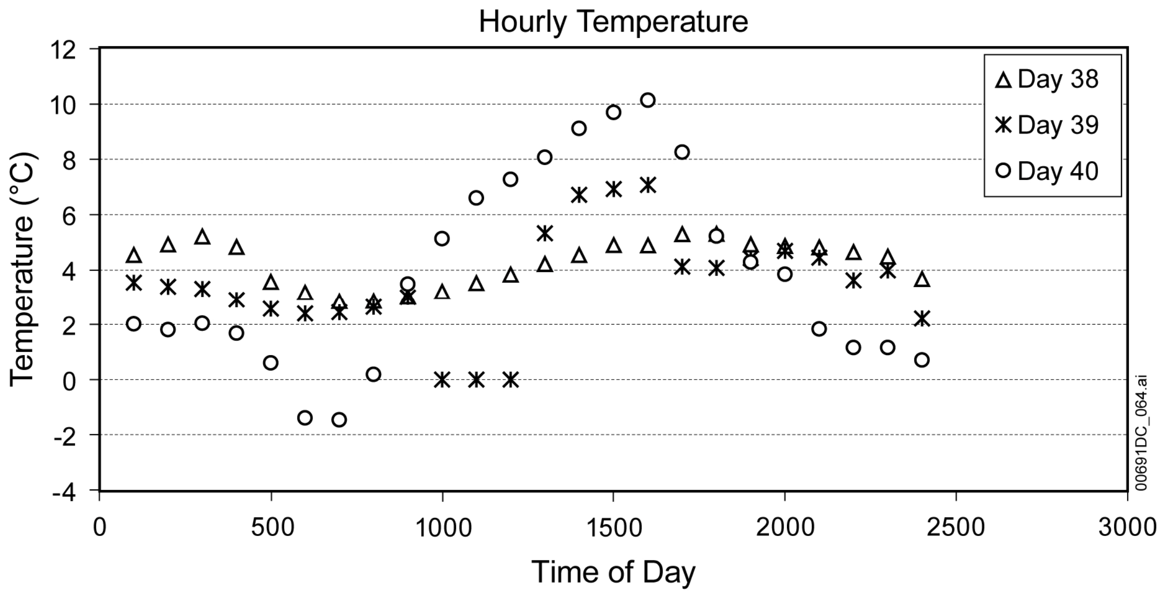
Hour	Day 229, 1994		Day 231, 1994	
	Hourly Temperature[a]	24H - (9-13)[b]	Hourly Temperature[a]	24H - (9-13)[b]
1	25.62	25.62	24.35	24.35
2	23.63	23.63	24.51	24.51
3	23.94	23.94	24.00	24.00
4	21.91	21.91	22.14	22.14
5	21.27	21.27	21.56	21.56
6	21.82	21.82	21.38	21.38
7	26.91	26.91	26.06	26.06
8	29.23	29.23	28.34	28.34
9	30.58	N/A	29.18	N/A
10	31.60	N/A	30.41	N/A
11	32.65	N/A	31.36	N/A
12	33.16	N/A	32.14	N/A
13	33.68	N/A	33.09	N/A
14	32.82	32.82	33.48	33.48
15	30.94	30.94	33.80	33.80
16	29.32	29.32	33.75	33.75
17	28.89	28.89	33.99	33.99
18	27.61	27.61	33.64	33.64
19	26.79	26.79	32.66	32.66
20	26.26	26.26	30.13	30.13
21	26.11	26.11	30.25	30.25
22	25.40	25.40	27.12	27.12
23	24.39	24.39	25.23	25.23
24	24.56	24.56	27.05	27.05
Mean Temp	27.46	26.18	28.73	28.08
Degree Difference		-1.28		-0.66

Source: Appendix F.

[a] Meaning "Complete Set of 24 Hourly Data Sets."

[b] Meaning "Hours 9 through 13 Omitted".

N/A = not applicable.



Source: Appendix F.

Figure E-6. Site 6 Hourly Temperature Data (military time) for Julian Days 38 ,39, and 40 (1994)

Hours of No Temperature Data – 1000, 1100, 1200

Figure E-6 shows both the minimum and maximum temperature recorded for Julian day 39. Average temperature values were derived using a complete set of data (i.e., 24 hourly data sets), and were compared to that derived after deleting the same three hours that were missing from the data for Julian day 39. The daily average differed between approximately 0.1 C and 0.36 C. The difference is of little concern, because this low most probably has already occurred.

Table E-9. Hourly Temperature Recorded at YM Site 6 on Julian Days 38 and 40, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values

	Day 38, 1994		Day 40, 1994	
Hour	Hourly Temperature[a]	24H - (10-12)[b]	Hourly Temperature[a]	24H - (10-12)[b]
1	4.542	4.54	2.01	2.01
2	4.926	4.93	1.809	1.81
3	5.208	5.21	2.038	2.04
4	4.825	4.83	1.682	1.68
5	3.56	3.56	0.601	0.60
6	3.176	3.18	–1.389	–1.39
7	2.843	2.84	–1.467	–1.47
8	2.863	2.86	0.181	0.18
9	3.015	3.02	3.49	3.49

Table E-9. Hourly Temperature Recorded at YM Site 6 on Julian Days 38 and 40, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values (Continued)

Hour	Day 38, 1994		Day 40, 1994	
	Hourly Temperature[a]	24H - (10-12)[b]	Hourly Temperature[a]	24H - (10-12)[b]
10	3.208	N/A	5.134	N/A
11	3.523	N/A	6.604	N/A
12	3.834	N/A	7.27	N/A
13	4.218	4.22	8.07	8.07
14	4.534	4.53	9.12	9.12
15	4.895	4.90	9.69	9.69
16	4.892	4.89	10.13	10.13
17	5.289	5.29	8.26	8.26
18	5.298	5.30	5.217	5.22
19	4.92	4.92	4.285	4.29
20	4.865	4.87	3.841	3.84
21	4.821	4.82	1.823	1.82
22	4.647	4.65	1.15	1.15
23	4.481	4.48	1.16	1.16
24	3.666	3.67	0.699	0.70
Mean Temp	4.25	4.36	3.81	3.45
Degree Difference		-0.10		-0.36

Source: Appendix F.

[a] Meaning "Complete Set of 24 Hourly Data Sets."
[b] Meaning "Hours 10 through 12 Omitted."

NA = not applicable.

In conclusion, the number of days for which there are missing hours are so few that any over- or underestimation in deriving predictions for present-day and future climate conditions using this set of inputs would be insignificant. Additionally, the error introduced by over- or underestimating a maximum value is small, given that of the days for which there are missing hourly data, most have only one or two hours of missing data. Further, this error would be inconsequential because the size of the complete 24 hourly data set overwhelms the much smaller size of the data set with missing hours.

APPENDIX F

ROADMAP FOR FIGURES AND TABLES PRESENTED IN THIS REPORT

Tables F-1 through F-8 list the figure numbers and source DTNs for each figure given in this report. In order to create many of these figures some of the source data needed reformatting.

A compact disk is included as part of Appendix F and consists of a set of Excel® roadmap files used to create the figures (and any related tables) discussed in the report. The files are stored in a compact disc entitled *EXCEL Workbooks Used to Create Figures and Related Tables Discussed in Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain (ANL-MGR-MD-000015 REV00*). The compact disk consists of folders, labeled by section number, where the Excel® files used to create each figure are located. In each folder there is an Excel® workbook that contains the roadmap giving the figure number, title, the source DTN number for each figure, and the Excel® workbooks and worksheets used to create each figure. The roadmap also contains the location (by worksheet and cell) within each Excel® workbook where the figure is located. Note that there are instances in which figure fonts, colors, and symbols were reformatted from that created in the Excel® workbooks to a format more appropriate for publication and insertion into this report.

Table F-1. Source for Section 6.1 Figures

Section 6.1 Figures	Figure Title	Source DTN
6.1-1	Yearly Precipitation at YM Sites 1, 2, 3, 6, and 9 (1993 through 2004)	SN0608WEATHER1.005
6.1-2	Average and Median Yearly Precipitation with Respect to Elevation for YM Sites 1, 2, 3, 6, and 9	SN0608WEATHER1.005 SN0612GEOCOORD.001
6.1-3	YM Site 1 Average 15-Day Interval Precipitation (1993 through 2004)	SN0608WEATHER1.005
6.1-4	YM Site 2 Average 15-Day Interval Precipitation (1993 through 2004)	SN0608WEATHER1.005
6.1-5	YM Site 3 Average 15-Day Interval Precipitation (1993 through 2004)	SN0608WEATHER1.005
6.1-6	YM Site 6 Average 15-Day Interval Precipitation (1993 through 2004)	SN0608WEATHER1.005
6.1-7	YM Site 9 Average 15-Day Interval Precipitation (1993 through 2004)	SN0608WEATHER1.005
6.1-8 top	YM Site 1 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation	SN0608WEATHER1.005
6.1-8 bottom		SN0608WEATHER1.005
6.1-9 top	YM Site 2 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation	SN0608WEATHER1.005
6.1-9 bottom		SN0608WEATHER1.005
6.1-10 top	YM Site 3 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation	SN0608WEATHER1.005
6.1-10 bottom		SN0608WEATHER1.005
6.1-11 top	YM Site 6 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation	SN0608WEATHER1.005
6.1-11 bottom		SN0608WEATHER1.005
6.1-12 top	YM Site 9 Daily Totals by Year (top) and Cumulative Daily Totals (bottom) of Recorded Precipitation	SN0608WEATHER1.005
6.1-12 bottom		SN0608WEATHER1.005
6.1-13	Cumulative Precipitation for YM Sites 1, 2, 3, 6, and 9 (1998 and 2002)	SN0608WEATHER1.005
6.1-14	Cumulative Precipitation for YM Sites 1, 2, 3, 6, and 9 (1995)	SN0608WEATHER1.005

Table F-1. Source for Section 6.1 Figures (Continued)

Section 6.1 Figures	Figure Title	Source DTN
6.1-15	Calculated Precipitation Rate for YM Site 1 (Julian Days 1 through 365 [or 366])	SN0608WEATHER1.005
6.1-16.	Calculated Precipitation Rate for YM Site 2 (Julian Days 1 through 365 [or 366])	SN0608WEATHER1.005
6.1-17	Calculated Precipitation Rate for YM Site 3 (Julian Days 1 through 365 [or 366])	SN0608WEATHER1.005
6.1-18	Calculated Precipitation Rate for YM Site 6 (Julian Days 1 through 365 [or 366])	SN0608WEATHER1.005
6.1-19	Calculated Precipitation Rate for YM Site 9 (Julian Days 1 through 365 [or 366])	SN0608WEATHER1.005
6.1-20	YM Site 1 Precipitation Rate Histogram for Years 1993 through 2004	SN0608WEATHER1.005
6.1-21	YM Site 2 Precipitation Rate Histogram for Years 1993 through 2004	SN0608WEATHER1.005
6.1-22	YM Site 3 Precipitation Rate Histogram for Years 1993 through 2004	SN0608WEATHER1.005
6.1-23	YM Site 6 Precipitation Rate Histogram for Years 1993 through 2004	SN0608WEATHER1.005
6.1-24	YM Site 9 Precipitation Rate Histogram for Years 1993 through 2004	SN0608WEATHER1.005
6.1-25	Minimum and Maximum Daily Temperatures Recorded at YM Site 2 (1993 to 2004)	SN0608WEATHER1.005
6.1-26	Daily Maximum Temperatures Averaged over 1993 through 2004	SN0608WEATHER1.005
6.1-27	Daily Minimum Temperatures Averaged over 1993 through 2004	SN0608WEATHER1.005
6.1-28	Average Maximum Temperature (1993 through 2004) at Temperature Inflection-Point Days and the Midpoint of the Spring and Fall Temperature Slopes for YM Sites 1, 2, 3, 6, and 9	SN0608WEATHER1.005
6.1-29	Average Minimum Temperature (1993 through 2004) at Temperature Inflection-Point Days and the Midpoint of the Temperature Slope Days for the Five YM Sites	SN0608WEATHER1.005
6.1-30	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 7 through 14	SN0608WEATHER1.005
6.1-31	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 7 through 14	SN0608WEATHER1.005
6.1-32	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 43 through 57	SN0608WEATHER1.005
6.1-33	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 43 through 57	SN0608WEATHER1.005
6.1-34	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 60 through 84	SN0608WEATHER1.005
6.1-35	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 60 through 84	SN0608WEATHER1.005
6.1-36	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 82 through 99	SN0608WEATHER1.005
6.1-37	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 82 through 99	SN0608WEATHER1.005

Table F-1. Source for Section 6.1 Figures (Continued)

Section 6.1 Figures	Figure Title	Source DTN
6.1-38	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998) Julian Days 100 through 117	SN0608WEATHER1.005
6.1-39	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 100 through 117	SN0608WEATHER1.005
6.1-40	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 156 through 166	SN0608WEATHER1.005
6.1-41	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 156 through 166	SN0608WEATHER1.005
6.1-42	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 200 through 206	SN0608WEATHER1.005
6.1-43	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 200 through 206	SN0608WEATHER1.005
6.1-44	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 240 through 253	SN0608WEATHER1.005
6.1-45	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 240 through 253	SN0608WEATHER1.005
6.1-46	Temperature and Precipitation for YM Sites 1, 2, and 3 (1998), Julian Days 330 through 335	SN0608WEATHER1.005
6.1-47	Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 330 through 335	SN0608WEATHER1.005
6.1-48	YM Site 1 Average Daily Wind Speed (1993 through 2004)	SN0608WEATHER1.005
6.1-49	YM Site 2 Average Daily Wind Speed (1993 through 2004)	SN0608WEATHER1.005
6.1-50	YM Site 3 Average Daily Wind Speed (1993 through Julian day 195, 1999)	SN0608WEATHER1.005
6.1-51	YM Site 6 Average Daily Wind Speed (1993 through Julian day 195, 1999)	SN0608WEATHER1.005
6.1-52	YM Site 9 Average Daily Wind Speed (1993 through 2004)	SN0608WEATHER1.005
6.1-53	Twelve-Year Average Daily Wind Speed for YM Sites 1, 2, and 9 (1993 through 2004), Six-and-a-Half-Year Average Daily Wind Speed for YM Sites 3 and 6 (1993 through 1998 and the first 195 days in 1999)	SN0608WEATHER1.005

Table F-2. Source for Section 6.2 Figures

Section 6.2 Figures	Figure Title	Source DTN
6.2-1	Annual and Period-of-Record Average of Precipitation at Amargosa Farms–Garey (1965 through 2004)	SN0601PRECPTMP.002
6.2-2	Daily Total Precipitation at Amargosa Farms–Garey (1965 through 2004)	SN0601PRECPTMP.002
6.2-3	Average Precipitation for 15-Day Intervals at Amargosa Farms–Garey (1965 through 2004)	SN0601PRECPTMP.002
6.2-4	Frequency Distribution for Average Annual Precipitation at Amargosa Farms–Garey (1965 through 2004)	SN0601PRECPTMP.002
6.2-5	Annual and Period-of-Record Average of Precipitation at Area 12 (1960 through 2004)	SN0601PRECPTMP.002
6.2-6	Daily Total Precipitation at Area 12 (1959 through 2004)	SN0601PRECPTMP.002
6.2-7	Average Precipitation for 15-Day Intervals at Area 12 (1960 through 2004)	SN0601PRECPTMP.002
6.2-8	Frequency Distribution for Average Annual Precipitation at Area 12 (1960 through 2004)	SN0601PRECPTMP.002
6.2-9	Annual and Period-of-Record Average of Precipitation at Site 4JA (1959 through 2004)	SN0601PRECPTMP.002
6.2-10	Daily Total Precipitation at Site 4JA (1959 through 2004)	SN0601PRECPTMP.002
6.2-11	Average Precipitation for 15-Day Intervals at Site 4JA (1959 through 2004)	SN0601PRECPTMP.002
6.2-12	Frequency Distribution for Average-Annual Precipitation at Site 4JA (1959 through 2004)	SN0601PRECPTMP.002
6.2-13	Annual and Period-of-Record Average of Precipitation at 40MN (1961 through 2004)	SN0601PRECPTMP.002
6.2-14	Daily Total Precipitation at 40MN (1961 through 2004)	SN0601PRECPTMP.002
6.2-15	Average Precipitation for 15-Day Intervals at 40MN (1961 through 2004)	SN0601PRECPTMP.002
6.2-16	Frequency Distribution for Average Annual Precipitation at 40MN (1961 through 2004)	SN0601PRECPTMP.002
6.2-17	Annual and Period-of-Record Average of Precipitation at Cane Springs (1965 through 2004)	SN0601PRECPTMP.002
6.2-18	Daily Total Precipitation at Cane Springs (1964 through 2004)	SN0601PRECPTMP.002
6.2-19	Average Precipitation for 15-Day Intervals at Cane Springs (1965 through 2004)	SN0601PRECPTMP.002
6.2-20	Frequency Distribution for Average Annual Precipitation at Cane Springs (1965 through 2004)	SN0601PRECPTMP.002
6.2-.21	Average Annual Precipitation Plus and Minus One Standard Deviation (One Sigma) and Extreme High and Low Precipitation Values	SN0601PRECPTMP.002
6.2-22	Average and Median Annual Precipitation with Respect to Elevation for Amargosa Farms–Garey, Area 12, Site 4JA, 40MN, and Cane Springs	SN0601PRECPTMP.002

Table F-2. Source for Section 6.2 Figures (Continued)

Section 6.2 Figures	Figure Title	Source DTN
6.2-23	Maximum Daily Temperatures and the Average Daily Maximum Temperature for Amargosa Farms–Garey (1993 through 2004)	SN0601PRECPTMP.002
6.2.24	Minimum Daily Temperatures and the Average Daily Minimum Temperature for Amargosa Farms–Garey (1993 through 2004)	SN0601PRECPTMP.002
6.2-25	Average Daily Maximum Temperature, Plus and Minus One Standard Deviation, Recorded at Amargosa Farms–Garey (1993 through 2004)	SN0601PRECPTMP.002
6.2-26	Average Daily Minimum Temperature, Plus and Minus One Standard Deviation, Recorded at Amargosa Farms–Garey (1993 through 2004)	SN0601PRECPTMP.002
6.2-27	Average Minimum, Average Maximum Temperature Values and Extreme High and Extreme High Low Average Values Recorded at Amargosa Farms–Garey (1965 through 2004)	SN0601PRECPTMP.002

Table F-3. Source for Section 6.3 Figures

Section 6.3 Figures	Figure Title	Source DTN
6.3-2	Annual and Average Precipitation at Nogales, Arizona (1948 through 1983)	SN0603DWEATHER.002
6.3-3	Daily Total Precipitation at Nogales, Arizona (1948 through 1983)	SN0603DWEATHER.002
6.3-4	Average Precipitation for 15-Day Intervals at Nogales, Arizona (1948 through to 1983)	SN0603DWEATHER.002
6.3-5	Histogram of Annual Precipitation at Nogales, Arizona (1948 through to 1983)	SN0603DWEATHER.002
6.3-6	Annual and Average Precipitation at Hobbs, New Mexico (1952 through 1999)	SN0603DWEATHER.002
6.3-7	Daily Total Precipitation at Hobbs, New Mexico (1952 through 1999)	SN0603DWEATHER.002
6.3-8	Average Precipitation for 15-Day Intervals at Hobbs, New Mexico (1952 through 1999)	SN0603DWEATHER.002
6.3-9	Histogram of Annual Precipitation at Hobbs, New Mexico (1952 through 1999)	SN0603DWEATHER.002
6.3-10	Annual and Average Precipitation at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-11	Daily Total Precipitation at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-12	Average Precipitation for 15-Day Intervals at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-13	Histogram of Annual Precipitation at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-14	Annual and Average Precipitation at Rosalia, Washington (1953 through 1994)	SN0603DWEATHER.002
6.3-15	Daily Total Precipitation at Rosalia, Washington (1953 through 1994)	SN0603DWEATHER.002
6.3-16	Average Precipitation for 15-Day Intervals at Rosalia, Washington (1953 through 1994)	SN0603DWEATHER.002

Table F-3. Source for Section 6.3 Figures (Continued)

Section 6.3 Figures	Figure Title	Source DTN
6.3-17	Histogram of Annual Precipitation at Rosalia, Washington (1953 through 1994)	SN0603DWEATHER.002
6.3-18	Annual and Average Precipitation at St. John, Washington (1964 through 2002)	SN0603DWEATHER.002
6.3-19	Daily Total Precipitation at St. John, Washington (1964 through 2002)	SN0603DWEATHER.002
6.3-20	Average Precipitation for 15-Day Intervals at St. John, Washington (1964 through 2002)	SN0603DWEATHER.002
6.3-21	Histogram of Annual Precipitation at St. John, Washington (1964 through 2002)	SN0603DWEATHER.002
6.3-22	Annual and Average Precipitation at Beowawe, Nevada (1983 through 2002)	SN0603DWEATHER.002
6.3-23	Daily Total Precipitation at Beowawe, Nevada (1983 through 2002)	SN0603DWEATHER.002
6.3-24	Average Precipitation for 15-Day Intervals at Beowawe, Nevada (1983 through 2002)	SN0603DWEATHER.002
6.3-25	Histogram of Annual Precipitation at Beowawe, Nevada (1983 through 2002)	SN0603DWEATHER.002
6.3-26	Annual and Average Precipitation at Delta, Utah (1972 through 2004)	SN0603DWEATHER.002
6.3-27	Daily Total Precipitation at Delta, Utah (1972 through 2004)	SN0603DWEATHER.002
6.3-28	Average Precipitation for 15-Day Intervals at Delta, Utah (1972 through 2004)	SN0603DWEATHER.002
6.3-29	Histogram of Annual Precipitation at Delta, Utah (1972 through 2004)	SN0603DWEATHER.002
6.3-30	Daily Maximum Temperatures Recorded at Beowawe, Nevada (1982 through 2004)	SN0603DWEATHER.002
6.3-31	Daily Minimum Temperatures Recorded at Beowawe, Nevada (1982 through 2004)	SN0603DWEATHER.002
6.3-32	Average Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Beowawe, Nevada (1982 through 2004)	SN0603DWEATHER.002
6.3-33	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Beowawe, Nevada (1982 through 2004)	SN0603DWEATHER.002
6.3-34	Daily Maximum Temperatures Recorded at Delta, Utah (1971 through 2004)	SN0603DWEATHER.002
6.3-35	Daily Minimum Temperatures Recorded at Delta, Utah (1968 through 2004)	SN0603DWEATHER.002
6.3-36	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Delta, Utah (1968 through 2004)	SN0603DWEATHER.002
6.3-37	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Delta, Utah (1968 through 2004)	SN0603DWEATHER.002
6.3-38	Daily Maximum Temperatures Recorded at Hobbs, New Mexico (1947 through 2004)	SN0603DWEATHER.002
6.3-39	Daily Minimum Temperatures Recorded at Hobbs, New Mexico (1947 through 2004)	SN0603DWEATHER.002

Table F-3. Source for Section 6.3 Figures (Continued)

Section 6.3 Figures	Figure Title	Source DTN
6.3-40	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Hobbs, New Mexico (1947 through 2004)	SN0603DWEATHER.002
6.3-41	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Hobbs, New Mexico (1947 through 2004)	SN0603DWEATHER.002
6.3-42	Daily Maximum Temperatures Recorded at Nogales, Arizona (1948 through 1982)	SN0603DWEATHER.002
6.3-43	Average Annual Daily Minimum Temperatures Recorded at Nogales, Arizona (1948 through 1982)	SN0603DWEATHER.002
6.3-44	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Nogales, Arizona (1948 through 1982)	SN0603DWEATHER.002
6.3-45	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Nogales, Arizona (1948 through 1982)	SN0603DWEATHER.002
6.3-46	Daily Maximum Temperatures Recorded at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-47	Daily Minimum Temperatures Recorded at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-48	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-49	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Spokane, Washington (1948 through 2004)	SN0603DWEATHER.002
6.3-50	Daily Maximum Temperatures Recorded at Rosalia, Washington (1949 through 2004)	SN0603DWEATHER.002
6.3-51	Daily Minimum Temperatures Recorded at Rosalia, Washington (1949 through 2004)	SN0603DWEATHER.002
6.3-52	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at Rosalia, Washington (1951 through 2004)	SN0603DWEATHER.002
6.3-53	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Rosalia, Washington (1951 through 2004)	SN0603DWEATHER.002
6.3-54	Daily Maximum Temperatures Recorded at St. John, Washington (1964 through 2004)	SN0603DWEATHER.002
6.3-55	Daily Minimum Temperatures Recorded at St. John, Washington (1963 through 2004)	SN0603DWEATHER.002
6.3-56	Average Annual Daily Maximum Temperature Plus and Minus One Standard Deviation Recorded at St. John, Washington (1963 through 2004)	SN0603DWEATHER.002
6.3-57	Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at St. John, Washington (1963 through 2004)	SN0603DWEATHER.002

Table F-4. Source for Section 6.4 Figures

Section 6.4 Figures	Figure Title	Source DTN
6.4-1a.	Minimum Daily Temperature Recorded at MEDA 12 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-1b	Maximum Daily Temperature Recorded at MEDA 12 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-2a	Minimum Daily Temperature Recorded at MEDA 26 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-2b	Maximum Daily Temperature Recorded at MEDA 26 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-3.	Maximum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 12 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-4.	Minimum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 12 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-5.	Maximum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 26 (1993 through 2004)	SN0603TEMPMEDA.002
6.4-6.	Minimum Daily Average Temperature, and Standard Deviation of the Average, Recorded at MEDA 26 (1993 through 2004)	SN0603TEMPMEDA.002

Table F-5. Source for Section 7 Figures

Section 7 Figures and Tables	Figure Title	Source DTN
Figure 7.1-1.	Average, Standard Deviation, and Extreme Values for Average Annual Precipitation	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603DWEATHER.002
Table 7.1-1	Average Annual Precipitation, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603DWEATHER.002
Figure 7.1-2.	Average Annual Precipitation versus Elevation at Meteorological Stations Representing Present-day Climate Conditions	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0612GEOCOORD.001
Figure 7.1-3 .	Average, Standard Deviation, and Extreme Values for Maximum Daily Temperature	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603DWEATHER.002 SN0603TEMPMEDA.002
Table 7.1-2	Average Maximum Temperature, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603DWEATHER.002 SN0603TEMPMEDA.002
Figure 7.1-4.	Average, Standard Deviation, and Extreme Values for Minimum Daily Temperature	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603DWEATHER.002 SN0603TEMPMEDA.002
Table 7.1-3	Average Minimum Temperature, and Standard Deviation, Calculated from Data Recorded at Meteorological Stations Representing Present-Day and Future Climate	SN0608WEATHER1.005SN0601PRECPTMP.002SN0603DWEATHER.002SN0603TEMPMEDA.002

Table F-5. Source for Section 7 Figures (Continued)

Section 7 Figures and Tables	Figure Title	Source DTN
Figure 7.1-5 .	Maximum Temperature with Respect to Elevation, Measured on Critical Days at 8 Sites within a 40 km Radius of Yucca Mountain	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603TEMPMEDA.002 SN0612GEOCOORD.001
Figure 7.1-6 .	Minimum Temperature with Respect to Elevation, Measured on Critical Days at Sites within a 40 km Radius of Yucca Mountain	SN0608WEATHER1.005 SN0601PRECPTMP.002 SN0603TEMPMEDA.002 SN0612GEOCOORD.001

Table F-6. Source for Appendix A Figures

Appendix A Figure	Figure Title	Source DTN
Figure A-1	Maximum Daily Temperatures for MEDA 26 and YM Site 1 Recorded in 1996 and Temperature Differences between the Two Stations	SN0608WEATHER1.005
		SN0603NTSMEDAW.001

Table F-7. Source for Appendix D Figures

Appendix D Figures	Figure Title	Source DTN
Figure D-1a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 2 through 9 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-1b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 2 through 9 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-1c	Temperature and Precipitation for Site 4JA–MEDA 26, Area12–MEDA 12, and Amargosa Farms–Garey between Julian Days 2 through 9 in 1995	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-2a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 8 through 12 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-2b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 8 through 12 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005

Table F-7. Source for Appendix D Figures (Continued)

Appendix D Figures	Figure Title	Source DTN
Figure D-2c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 8 through 12 in 1995	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-3a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 18 through 28 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-3b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 18 through 28 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-3c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 18 through 28 in 1995	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-4a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 138 through 160 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-4b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 138 through 160 in 1995	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-4c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 138 through 160 in 1995	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-5a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 7 through 14 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-5b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 7 through 14 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-5c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 7 through 14 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002

Table F-7. Source for Appendix D Figures (Continued)

Appendix D Figures	Figure Title	Source DTN
Figure D-6a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 28 through 42 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-6b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 28 through 42 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-6c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 28 through 42 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-7a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 43 through 57 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-7b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 43 through 57 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-7c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 43 through 57 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-8a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 100 through 117 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-8b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 100 through 117 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-8c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 100 through 117 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-9a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 156 through 166 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-9b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 156 through 166 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005

Table F-7. Source for Appendix D Figures (Continued)

Appendix D Figures	Figure Title	Source DTN
Figure D-9c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 156 through 166 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-10a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 200 through 206 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-10b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 200 through 206 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-10c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 200 through 206 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-11a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 240 through 253 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-11b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 240 through 253 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-11c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 240 through 253 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-12a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 330 through 335 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-12b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 330 through 335 in 1998	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-12c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 330 through 335 in 1998	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002

Table F-7. Source for Appendix D Figures (Continued)

Appendix D Figures	Figure Title	Source DTN
Figure D-13a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 74 through 79 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-13b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 74 through 79 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-13c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 74 through 79 in 2002	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-14a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 196 through 201 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-14b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 196 through 201 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-14c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 196 through 201 in 2002	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-15a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 310 through 314 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-15b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 310 through 314 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-15c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 310 through 314 in 2002	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
Figure D-16a	Temperature and Precipitation for YM Site 1, YM Site 2, and YM Site 3 between Julian Days 349 through 357 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
		SN0608WEATHER1.005

Table F-7. Source for Appendix D Figures (Continued)

Appendix D Figures	Figure Title	Source DTN
Figure D-16b	Temperature and Precipitation for YM Site 6 and YM Site 9 between Julian Days 349 through 357 in 2002	SN0608WEATHER1.005
		SN0608WEATHER1.005
Figure D-16c	Temperature and Precipitation for Site 4JA–MEDA 26, Area 12–MEDA 12, and Amargosa Farms–Garey between Julian Days 349 through 357 in 2002	SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002
		SN0603NTSMEDAW.001
		SN0601PRECPTMP.002

Table F-8. Source for Appendix E Figures

Appendix E Figures and Tables	Figure Title	Source DTN
Table E-1	Number of Days, between 1994 through 2004, Where a Minimum, Maximum, and Average Daily Temperature Is Determined Using Fewer Than the Full Set of 24 Hourly-Temperature Measurements for YM Site Stations 1, 2, 3, 6, and 9	SN0608WEATHER1.005
Table E-2	Calculated Average Temperature Derived by Eliminating One to Five Hours of Hourly Data	SN0608WEATHER1.005
Figure E-1	Hourly Temperature at YM Site 1 (Julian days 131 through 133 and 200 through 202	SN0608WEATHER1.005
Table E-3	Hourly Temperature (°C) Recorded at YM Site 1 on Julian Days 131 and 133 of 2004, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values	SN0608WEATHER1.005
Table E-4	Hourly Temperature Recorded at YM Site 1 on Julian Days 200 and 202 of 2004, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values	SN0608WEATHER1.005
Table E-5	Site 1 – Comparison of Daily Average Temperatures (°C) Derived Using 24 Hourly Temperature Values for Each Hour of the Day and Averages Derived Using Fewer Than 24 Hourly Temperature Values	SN0608WEATHER1.005
Figure E-2	Site 1 – Temperature Differences for Computed Daily Averages Using 24 One-Hour Temperatures, and Averages Derived Using Fewer Than the Full Set of 24 Measurements	SN0608WEATHER1.005
Table E-6	Site 2 – Comparison of Daily Average Temperature Derived Using 24 Hourly Temperature Values for Each Hour of the Day and Averages Derived Using Less Than the Full 24 Hour Set Values	SN0608WEATHER1.005

Table F-8. Source for Appendix E Figures (Continued)

Appendix E Figures and Tables	Figure Title	Source DTN
Figure E-3	Site 1 – Temperature Differences for Computed Daily Averages Using 24 One-Hour Temperatures, and Averages Derived Using Fewer Than the Full Set of 24 Measurements	SN0608WEATHER1.005
Table E-7	Hourly Temperature Recorded at YM Site 6 on Julian Days 74 and 76, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values	SN0608WEATHER1.005
Figure E-4	Site 6 Hourly Temperature Data for Julian Days 74, 75, and 76 (1994)	SN0608WEATHER1.005
Figure E-5	Site 6 Hourly Temperature Data for Julian Days 229, 230, and 231 (1994)	SN0608WEATHER1.005
Table E-8	Hourly Temperature Recorded at YM Site 6 on Julian Days 229 and 231, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values	SN0608WEATHER1.005
Figure E-6	Site 6 Hourly Temperature Data for Julian Days 38, 39, and 40 (1994)	SN0608WEATHER1.005
Table E-9	Hourly Temperature Recorded at YM Site 6 on Julian Days 38 and 40, 1994, and Calculated Average Temperature Using All Hourly Temperature Values and an Average with Fewer Hourly Values	SN0608WEATHER1.005

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APPENDIX G

TABLES FOR CONVERTING JULIAN DAYS TO GREGORIAN DAYS

This appendix provides tables for converting Julian days to Gregorian days because Julian days are used to throughout this report to identify the days of the year when significant meteorological events occurred. Table G-1 is for use in leap years and Table G-2 is for use in non-leap years.

Table G-1. Leap Year Conversion from Julian Day to Gregorian Day

Gregorian Day of Month	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	Julian Day											
1	*1*	*32*	*61*	*92*	*122*	*153*	*183*	*214*	*245*	*275*	*306*	*336*
2	*2*	*33*	*62*	*93*	*123*	*154*	*184*	*215*	*246*	*276*	*307*	*337*
3	*3*	*34*	*63*	*94*	*124*	*155*	*185*	*216*	*247*	*277*	*308*	*338*
4	*4*	*35*	*64*	*95*	*125*	*156*	*186*	*217*	*248*	*278*	*309*	*339*
5	*5*	*36*	*65*	*96*	*126*	*157*	*187*	*218*	*249*	*279*	*310*	*340*
6	*6*	*37*	*66*	*97*	*127*	*158*	*188*	*219*	*250*	*280*	*311*	*341*
7	*7*	*38*	*67*	*98*	*128*	*159*	*189*	*220*	*251*	*281*	*312*	*342*
8	*8*	*39*	*68*	*99*	*129*	*160*	*190*	*221*	*252*	*282*	*313*	*343*
9	*9*	*40*	*69*	*100*	*130*	*161*	*191*	*222*	*253*	*283*	*314*	*344*
10	*10*	*41*	*70*	*101*	*131*	*162*	*192*	*223*	*254*	*284*	*315*	*345*
11	*11*	*42*	*71*	*102*	*132*	*163*	*193*	*224*	*255*	*285*	*316*	*346*
12	*12*	*43*	*72*	*103*	*133*	*164*	*194*	*225*	*256*	*286*	*317*	*347*
13	*13*	*44*	*73*	*104*	*134*	*165*	*195*	*226*	*257*	*287*	*318*	*348*
14	*14*	*45*	*74*	*105*	*135*	*166*	*196*	*227*	*258*	*288*	*319*	*349*
15	*15*	*46*	*75*	*106*	*136*	*167*	*197*	*228*	*259*	*289*	*320*	*350*
16	*16*	*47*	*76*	*107*	*137*	*168*	*198*	*229*	*260*	*290*	*321*	*351*
17	*17*	*48*	*77*	*108*	*138*	*169*	*199*	*230*	*261*	*291*	*322*	*352*
18	*18*	*49*	*78*	*109*	*139*	*170*	*200*	*231*	*262*	*292*	*323*	*353*
19	*19*	*50*	*79*	*110*	*140*	*171*	*201*	*232*	*263*	*293*	*324*	*354*
20	*20*	*51*	*80*	*111*	*141*	*172*	*202*	*233*	*264*	*294*	*325*	*355*
21	*21*	*52*	*81*	*112*	*142*	*173*	*203*	*234*	*265*	*295*	*326*	*356*
22	*22*	*53*	*82*	*113*	*143*	*174*	*204*	*235*	*266*	*296*	*327*	*357*
23	*23*	*54*	*83*	*114*	*144*	*175*	*205*	*236*	*267*	*297*	*328*	*358*
24	*24*	*55*	*84*	*115*	*145*	*176*	*206*	*237*	*268*	*298*	*329*	*359*
25	*25*	*56*	*85*	*116*	*146*	*177*	*207*	*238*	*269*	*299*	*330*	*360*
26	*26*	*57*	*86*	*117*	*147*	*178*	*208*	*239*	*270*	*300*	*331*	*361*
27	*27*	*58*	*87*	*118*	*148*	*179*	*209*	*240*	*271*	*301*	*332*	*362*
28	*28*	*59*	*88*	*119*	*149*	*180*	*210*	*241*	*272*	*302*	*333*	*363*
29	*29*	*60*	*89*	*120*	*150*	*181*	*211*	*242*	*273*	*303*	*334*	*364*
30	*30*		*90*	*121*	*151*	*182*	*212*	*243*	*274*	*304*	*335*	*365*
31	*31*		*91*		*152*		*213*	*244*		*305*		*366*

Source: Modified from Beyer 1987 [DIRS 103805], p. 1.

Table G-2. Non-Leap Year Conversion from Julian Day to Gregorian Day

Gregorian Day of Month	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Julian Day											
1	*1*	*32*	*60*	*91*	*121*	*152*	*182*	*213*	*244*	*274*	*305*	*335*
2	*2*	*33*	*61*	*92*	*122*	*153*	*183*	*214*	*245*	*275*	*306*	*336*
3	*3*	*34*	*62*	*93*	*123*	*154*	*184*	*215*	*246*	*276*	*307*	*337*
4	*4*	*35*	*63*	*94*	*124*	*155*	*185*	*216*	*247*	*277*	*308*	*338*
5	*5*	*36*	*64*	*95*	*125*	*156*	*186*	*217*	*248*	*278*	*309*	*339*
6	*6*	*37*	*65*	*96*	*126*	*157*	*187*	*218*	*249*	*279*	*310*	*340*
7	*7*	*38*	*66*	*97*	*127*	*158*	*188*	*219*	*250*	*280*	*311*	*341*
8	*8*	*39*	*67*	*98*	*128*	*159*	*189*	*220*	*251*	*281*	*312*	*342*
9	*9*	*40*	*68*	*99*	*129*	*160*	*190*	*221*	*252*	*282*	*313*	*343*
10	*10*	*41*	*69*	*100*	*130*	*161*	*191*	*222*	*253*	*283*	*314*	*344*
11	*11*	*42*	*70*	*101*	*131*	*162*	*192*	*223*	*254*	*284*	*315*	*345*
12	*12*	*43*	*71*	*102*	*132*	*163*	*193*	*224*	*255*	*285*	*316*	*346*
13	*13*	*44*	*72*	*103*	*133*	*164*	*194*	*225*	*256*	*286*	*317*	*347*
14	*14*	*45*	*73*	*104*	*134*	*165*	*195*	*226*	*257*	*287*	*318*	*348*
15	*15*	*46*	*74*	*105*	*135*	*166*	*196*	*227*	*258*	*288*	*319*	*349*
16	*16*	*47*	*75*	*106*	*136*	*167*	*197*	*228*	*259*	*289*	*320*	*350*
17	*17*	*48*	*76*	*107*	*137*	*168*	*198*	*229*	*260*	*290*	*321*	*351*
18	*18*	*49*	*77*	*108*	*138*	*169*	*199*	*230*	*261*	*291*	*322*	*352*
19	*19*	*50*	*78*	*109*	*139*	*170*	*200*	*231*	*262*	*292*	*323*	*353*
20	*20*	*51*	*79*	*110*	*140*	*171*	*201*	*232*	*263*	*293*	*324*	*354*
21	*21*	*52*	*80*	*111*	*141*	*172*	*202*	*233*	*264*	*294*	*325*	*355*
22	*22*	*53*	*81*	*112*	*142*	*173*	*203*	*234*	*265*	*295*	*326*	*356*
23	*23*	*54*	*82*	*113*	*143*	*174*	*204*	*235*	*266*	*296*	*327*	*357*
24	*24*	*55*	*83*	*114*	*144*	*175*	*205*	*236*	*267*	*297*	*328*	*358*
25	*25*	*56*	*84*	*115*	*145*	*176*	*206*	*237*	*268*	*298*	*329*	*359*
26	*26*	*57*	*85*	*116*	*146*	*177*	*207*	*238*	*269*	*299*	*330*	*360*
27	*27*	*58*	*86*	*117*	*147*	*178*	*208*	*239*	*270*	*300*	*331*	*361*
28	*28*	*59*	*87*	*118*	*148*	*179*	*209*	*240*	*271*	*301*	*332*	*362*
29	*29*		*88*	*119*	*149*	*180*	*210*	*241*	*272*	*302*	*333*	*363*
30	*30*		*89*	*120*	*150*	*181*	*211*	*242*	*273*	*303*	*334*	*364*
31	*31*		*90*		*151*		*212*	*243*		*304*		*365*

Source: Modified from Beyer 1987 [DIRS 103805], p. 1.

APPENDIX H

QUALIFICATION OF GEOGRAPHIC COORDINATES AND ELEVATIONS OF YUCCA MOUNTAIN METEOROLOGICAL MONITORING SITES 1, 2, 3, 6, 8, AND 9

The appendix includes the qualification of the spatial location coordinates and the elevation of six Yucca Mountain meteorological monitoring sites. The location information is considered unqualified project data per SCI-PRO-005 and is qualified within this document per SCI-PRO-001 to provide a desired level of confidence that the data are suitable for the intended use of displaying the locations on a map and for linear regression calculations (see facsimile of Data Qualification Plan included at the end of this appendix).

H.1 DATA SET FOR QUALIFICATION

The meteorological monitoring site geographic coordinate and elevation data for sites 1, 2, 3, 6, 8, and 9 (Table H-1) are from *Technical Work Plan for Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722], Table A-1).

Table H-1. Geographic Coordinates and Elevations for Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9

Site	UTM Coordinates, NAD27 Zone 11 (m)	Nevada State Plane Coordinates (ft)	Longitude–Latitude (deg° min' sec'')	Elevation (above mean sea level)
Site 1 (NTS-60)	550,784E 4,077,374N	569,126E 761,795N	116°25'50''W 36°50'34''N	3,750 ft 1,143 m
Site 2 (Yucca Mountain)	547,646E 4,078,753N	558,844E 766,356N	116°27'56''W 36°51'19''N	4,850 ft 1,478 m
Site 3 (Coyote Wash)	548,874E 4,078,701N	562,874E 766,171N	116°27'06''W 36°51'17''N	4,195 ft 1,279 m
Site 6 (WT-6)	549,388E 4,083,097N	564,612E 780,592N	116°26'45''W 36°53'40''N	4,315 ft 1,315 m
Site 8 (Knothead Gap)	551,161E 4,075,773N	570,344E 756,538N	116°25'35''W 36°49'42''N	3,710 ft 1,131 m
Site 9 (G-510)	553,418E 4,058,398N	577,554E 699,491N	116°24'08''W 36°40'17''N	2,750 ft 838 m

Source: BSC 2006 [DIRS 176722], Table A-1.

NOTE: UTM = Universal Transverse Mercator.

The geographic information (elevation and location) for the six meteorological monitoring sites presented in Table H-1 are used for three purposes. First, in order to assess the present-day climate conditions within the Yucca Mountain vicinity, meteorological monitoring stations needed to be selected that lie within the area. Therefore, it was necessary to know the coordinates of the meteorological stations selected relative to the repository footprint. Second, the six meteorological monitoring site coordinates are used to produce maps that display the location of the sites with respect to other features on the Yucca Mountain site and with respect to each other. Third, several linear regression analyses are performed to establish linear relationships between elevation and the meteorological parameters measured at the sites (such as precipitation or temperature). These relationships are used to demonstrate any correlation between several meteorological parameters with elevation and predict, by the downstream user, possible changes in meteorological parameters with changes in elevation.

H.1.1 Initial Evaluation of the Data Quality and Correctness

The first step in this process is to locate survey records that support the data needing to be qualified. There are available records of the measured geographic coordinates and elevations for Sites 1, 2, 3, 6, 8 and 9 from project documents and letters submitted in 1996 to the YMP records center. These are "Request for Meteorological Data (SCPB: 8.3.1.12)" (Dixon 1996 [DIRS 178471], p. 6) and *Study Plan for Meteorological Data Collection at the Yucca Mountain Site, Revision 2* (CRWMS M&O 1996 [DIRS 178472], p. 2-5). The spatial coordinates for the sites (in Nevada State Plane and longitude/latitude) are described as having been obtained from Global Positioning System (GPS) measurements made either in late December 1992 or early January 1993 (as noted in Azhikakath 1993 [DIRS 178473]). The 1992-1993 survey was performed by Reynolds Electrical & Engineer Co. Inc (REECo), in response to a request for GPS coordinates for nine meteorological stations (and one antenna) located in the vicinity of Area 25. The REECo response was made on behalf of the Nuclear Waste Department of Westinghouse Electric Corporation.

The 1992-1993 survey resulted in elevation values and geographic coordinates for nine YMP meteorological monitory sites. Six of the nine surveyed sites pertain to this analysis and are listed in Table H-1. Their horizontal coordinates and vertical elevations are listed in Table H-2. The units for the Nevada State Plane coordinates are not stated. However, by convention the units for Nevada State Plane coordinates and elevation are given in feet. Therefore, and by convention, it is inferred that the coordinates presented in the REECo survey (see Azhikakath 1993 [DIRS 178473]) are in feet.

A first step in this analysis is to compare the values listed in Table H-1 with the results from the 1992-1993 survey. When the Nevada State Plane coordinates from Tables H-1 and H-2 are rounded to the nearest foot, the coordinates are identical. The longitude–latitude values provided in the two tables, when rounded to the nearest second, are also identical. The elevation values provided in Table H-1 appear to be rounded to the nearest 5-ft increment. With the exception of Site 8, elevation values rounded to the nearest 5-ft increment are comparable. There is a 25-ft discrepancy for Site 8 elevation between those given in Tables H-1 and H-2. With the exception of Site 8, this step appears to confirm that the values listed in Table H-1 are consistent with surveyed values of which a record exists.

The second step is to look at the pedigree of the 1992-1993 data used to compare with the values in Table H-1. The methods used to plan, collect, and perform the 1992-1993 geographic survey (listed in Table H-2) are not well documented. However, staff employed by REECo performed the survey. At the time of the survey, REECo was a member of the Nevada Test Site M&O and supporting nuclear weapons testing. It is expected that REECo followed procedures and processes that meet or exceed industry standards. Because the GPS survey records (Azhikakath 1993 [DIRS 178473]) provide actual control and field station identification numbers, time of survey, correction factors, and *XPDOP* numbers (a number that quantifies the degree of alignment between the various satellites used for positioning and the point on the earth's surface being measured), it is implied the pedigree of the REECo survey is of good standing. Furthermore, the REECo survey coordinates and measured elevations are similar to those given in Table H-1 for the six meteorological monitoring sites. Given these first few steps in this assessment, adequate rationale exists to proceed with the data qualification of the values listed in Table H-1.

Table H-2. Geographic Coordinates and Elevations for Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9 from GPS measurements

Site	Nevada State Plane Coordinates (feet)[a]	Longitude–Latitude (deg° min' sec'')[a]	Elevation (feet above mean sea level)[a]	NSP Diff[b] (ft)	Lon-Lat Diff[c] (second)	ELV Diff[d] (ft)
Site 1 (NTS-60)	569,126.38E 761,794.64N	116°25'49.53631''W 36°50'33.90165''N	3,752.07 ft	0E 0N	0''W 0''N	0
Site 2 (Yucca Mountain)	558,843.89E 766,355.84N	116°527'56.92316''W 36°51'19.13922''N	4,850.54 ft	0E 0N	0''W 0''N	0
Site 3 (Coyote Wash)	562,873.75E 766,171.13N	116°27'06.13409''W 36°51'17.22567''N	4,195.49 ft	0E 0N	0''W 0''N	0
Site 6 (WT-6)	564,612.05E 780,591.66N	116°26'44.54076''W 36°53'39.78806''N	4,316.44 ft	0E 0N	0''W 0''N	0
Site 8 (Knothead Gap)	570,344.00E 756,538.00N	116°25'34.71862''W 36°49'41.78954''N	3,684.00 ft	0E 0N	0''W 0''N	25
Site 9 (G-510)	577,554.21E 699,491.33N	116°24'07.96655''W 36°40'17.46919''N	2,754.13 ft	0E 0N	0''W 0''N	0

(a) Source: Azhikakath 1993 [DIRS 178473].
(b) NSP Diff is the difference between Nevada State Plane Coordinates given in Table H-1 and this table when round to the nearest foot.
(c) Lat-Long Diff is the difference between longitude and latitude (deg° min' sec') coordinates given in Table H-1 and values in this table when rounded to the nearest second.
(d) ELV Diff is the difference between elevations (rounded to the nearest 5-ft increment) given in Table H-1 and this table when rounded to the nearest 5-ft interval.

H.2 DATA EVALUATION CRITERIA

Two different criteria are developed to assess the acceptance of the monitoring site locations and elevations listed in Table H-1. The first criterion refers to the spatial location as portrayed on a map. For the purposes of plotting the data on a map printed on an 8.5×11 inch page, an error in the location of 0.01 inch is considered acceptable on the figure. At the scale of the maps presented in this document (the smallest scale is 2.7 km per inch), an error of 0.01 inch is equal to a coordinate error of 27 m. Therefore, the spatial coordinates are considered corroborated if the values are less than 27 m apart.

The second criterion relates to elevation. The criterion is determined by examining figures in the document where elevation of the measurement site is plotted and used in a linear regression analysis. To examine the error tolerance in an elevation value, a regression was reformulated to treat elevation as the dependent variable. When the regression is performed, it is possible to identify the standard error of the Y estimate. When elevation is plotted versus precipitation, the standard error of the elevation estimate is greater than 135 m. When elevation is plotted versus temperature, the standard error of the elevation estimate is about 20 m (because there is less variability in the temperature data than in the precipitation data). Assuming the differences in elevation are random (i.e., some are high and some are low), then a difference in elevation of 20 m is considered acceptable for the purpose of this analysis report.

H.3 METHOD OF QUALIFICATION

The method chosen for qualifying this data is the corroborating method. This method is appropriate because there exists corroborating geographic data available for comparison to the data set listed in Table H-1. Using the corroboration method, inferences can be drawn, clearly identified, justified, and documented.

To further corroborate the geographic coordinates and elevation given in Table H-1 (and implicitly to support the values given in Table H-2), additional site survey data are used.

H.3.1 Corroborating Technical Correctness of Geographic Coordinates

An old record exists of a geographic survey conducted in early 1985. The intention of the survey was to establish layout coordinates for five meteorological monitoring stations within the Yucca Mountain vicinity. The survey is documented in a June 3, 1985, field record entitled "Holmes & Narver Survey of Meteorological Site 1, 2, 3, 4, and 5" (Holmes & Narver 1985 [DIRS 178474]). (Note that the coordinates for YM Sites 4 and 5 are not used in this report.) The record states that the survey was to provide layout coordinates, not as-built coordinates, for five meteorological monitoring sites. Hence, it is expected that the actual as-built locations may not be the same once a monitoring site is erected. The 1985 survey reports the layout locations as Nevada State Plane coordinates. The geographic coordinates from the 1985 survey for Sites 1, 2, and 3 are presented in Table H-3.

Another survey was performed in 1992. In this survey, the positions of five meteorological monitoring sites were measured using a GPS. Documentation of the 1992 survey is provided in the field record entitled "Global Positioning System Data of Meteorological Sites 2, 6, 7, 8, and 9 in October 1992)" (CRWMS M&O 1992 [DIRS 178475]). The coordinates for Sites 6, 8, and 9 from this 1992 survey are given in Table H-3.

The top half of Table H-4 compares the Nevada State Plane coordinates presented in Tables H-1 and H-3 for Sites 1, 2, and 3. The column labeled "Difference between Values" gives the difference, in feet, between that reported in the 1985 layout survey and values listed in Table H-1. The maximum difference between the coordinates is (rounded to) ~78 ft (23 m). Given that the geographic survey identified in Table H-3 presents the layout (planned) locations and not the actual as-built locations, the similarity of values, while not an exact match, is quite good. The differences may be a combination of surveying errors and the possibility that upon construction of the sites the as-built locations had to be slightly moved due to unforeseen obstacles arising during the construction process.

The bottom half of Table H-4 is a comparison of the longitude–latitude coordinates listed in Tables H-1 and H-3 (from the GPS survey) for Sites 6, 8, and 9 is given in Table H-4. The column labeled "Difference between Values" gives the difference, in seconds, between that reported in the 1992 GPS survey and values listed in Table H-1. The sets of coordinates for Sites 6, 8 and 9 differ by at most two seconds of longitude or latitude, which equates to a difference in location of at most 220 ft (67 m).

Table H-3. Geographic Coordinates for Meteorological Monitoring Sites 1, 2, 3, from the Layout Survey and Coordinates for Sites 2, 6, 8, and 9 from GPS Measurements

Site	Nevada State Plane Coordinates (ft)	Longitude–Latitude (deg° min' sec'')
Site 1 [(a)] (NTS-60)	569,126.878E 761,795.219N	Not Available
Site 2 [(a)] (Yucca Mountain)	558,862.218E 766,433.636N	116°27'55''W 36°51'19''N
Site 3 [(a)] (Coyote Wash)	562,876.394E 766,194.889N	Not Available
Site 6 [(b)] (WT-6)	Not Available	116°26'45''W 36°53'39''N
Site 8 [(b)] (Knothead Gap)	Not Available	116°25'34''W 36°49'40''N
Site 9 [(b)] (G-510)	Not Available	116°24'07''W 36°40'15''N

(a) Source: Holmes & Narver 1985 [DIRS 178474] (Nevada State Plane Coordinates).
(b) Source: CRWMS M&O 1992 [DIRS 178475] (Longitude–Latitude).

Table H-4. Comparison between the Geographic Coordinates for Meteorological Monitoring Sites 1, 2, 3, from the Layout Survey, Sites 6, 8, and 9 from GPS Measurements to Coordinates Presented in Table H-1

Site	From Table H-1 Nevada State Plane Coordinates [(a)] (feet)	From Table H-3 Nevada State Plane Coordinates [(b)] (feet)	Difference between Values (feet)
Site 1 (NTS-60)	569,126.878E 761,795.219N	569,126E 761,795N	0.878E 0.219N
Site 2 (Yucca Mountain)	558,862.218E 766,433.636N	558,844E 766,356N	18.218E 77.636N
Site 3 (Coyote Wash)	562,876.394E 766,194.889N	562,874E 766,171N	2.39E 23.889N
Site	**From Table H-1 Longitude–Latitude [(a)] (deg° min' sec'')**	**From Table H-3 Longitude–Latitude [(c)] (deg° min' sec'')**	**Difference between Values (degree, minute, second)**
Site 2 (Yucca Mountain)	116°27'56''W 36°51'19''N	116°27'55''W 36°51'19''N	01"W 00"N
Site 6 (WT-6)	116°26'45''W 36°53'40''N	116°26'45''W 36°53'39''N	00"W 01"N
Site 8 (Knothead Gap)	116°25'35''W 36°49'42''N	116°25'34''W 36°49'40''N	01"W 02"N
Site 9 (G-510)	116°24'08''W 36°40'17''N	116°24'07''W 36°40'15''N	01"W 02"N

(a) Source: BSC 2006 [DIRS 176722], Table A-1.
(b) Source: Holmes & Narver 1985 [DIRS 178474] (Nevada State Plane Coordinates).
(c) Source: CRWMS M&O 1992 [DIRS 178475] (Longitude–Latitude).

The large difference between the two longitude–latitude coordinates may be due to the degree of precision used in recording the GPS reading. The GPS coordinates presented in Table H-3 were the result of a survey conducted by Mr. Jeffery Tappen, Principle Engineer for Westinghouse Electric Corporation, on October 15, 1992. Based on the record, the process used by Mr. Tappen included the use of a control station and a field station. He recorded the coordinates to the nearest second of longitude and latitude and not less. One second of longitude or latitude equates to approximately 100 ft (30 m). Thus, one would expect errors between the two sets of measurements to be at least 30 m. As the evaluation criterion for spatial location was set at 27 m, it is likely that inconsistencies between the longitude and latitude values in Tables H-1 and H-3 will exceed the criteria. As a result, the differences between the coordinates provided in the October 1992 GPS survey (CRWMS M&O 1992 [DIRS 178475]) and the data in Table H-1 do not necessarily indicate a failure to corroborate the location data in Table H-1. Furthermore, Mr. Tappen's measurements appear to be a preliminary survey. Available records suggest that this was the case. This conclusion is supported by documentation of a request to REECo, approximately two months later (on December 21, 1992), to provide another site survey. The results of this later survey are the values listed in Table H-2 (Azhikakath 1993 [DIRS 178473]). The coordinates from the later survey (listed in Table H-2) are recorded at a higher level of precision for all the monitoring sites, including Sites 6, 8, and 9, than those given in Table H-3, and should be considered as having a higher degree of defensibility in this corroboration process.

The corroborating values, thus far, are either in Nevada State Plane coordinates or longitude–latitude. No corroborations were available for the UTM coordinates. To corroborate the UTM values, the Nevada State Plane coordinates, listed in Table H-2, a product of the 1992-1993 survey (Azhikakath 1993 [DIRS 178473]), were converted to both UTM Zone 11 NAD27 and longitude–latitude coordinates using CORPSCON V5.11.08 (see Section 3.2) running on a PC with the Windows NT operating system. These converted values are given in Table H-5 and, when rounded to the nearest meter, match those in Table H-1 exactly. When rounded to the nearest second of longitude and latitude, the longitude and latitude values also compare exactly.

A final comparison of the geographic coordinates is provided by a confirmatory survey of Site 1 in 1997 (YMP 1997 [DIRS 178476], p. 5). The value of the Site 1 location in Nevada State Plane coordinates are 569,127.073E and 761796.168N with an elevation of 3,752.12 ft. These values compare well with the coordinates in Table H-1.

Table H-5. Geographic Coordinates Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9 from Converted from Nevada State Plane Coordinates to UTM and Latitude–Longitude Coordinates

Site	Table H-1 UTM Coordinates, NAD27 Zone 11 (m)	*Derived* UTM Coordinates, NAD27 Zone 11 from Nevada State Plan Coordinates (m)	Table H-1 Longitude–Latitude (deg° min' sec'')	*Derived* Longitude–Latitude (deg° min' sec'')
Site 1 (NTS-60)	550,784E 4,077,374N	550,784E 4,077,374N	116°25'50"W 36°50'34"N	116°25'50"W 36°50'34"N
Site 2 (Yucca Mountain)	547,646E 4,078,753N	547,646E 4,078,753N	116°27'56"W 36°51'19"N	116°27'56"W 36°51'19"N
Site 3 (Coyote Wash)	548,874E 4,078,710N	548,874E 4,078,710N	116°27'06"W 36°51'17"N	116°27'06"W 36°51'17"N
Site 6 (WT-6)	549,388E 4,083,097N	549,388E 4,083,097N	116°26'45"W 36°53'40"N	116°26'35"W 36°53'40"N
Site 8 (Knothead Gap)	551,161E 4,075,773N	551,161E 4,075,773N	116°25'35"W 36°49'42"N	116°25'35"W 36°49'42"N
Site 9 (G-510)	553,418E 4,058,398N	553,418E 4,058,398N	116°24'08"W 36°40'17"N	116°24'08"W 36°40'17"N

Source: BSC 2006 [DIRS 176722], Table A-1.

NOTE: UTM = Universal Transverse Mercator.

H.3.2 Corroborating and Technical Correctness of Elevation Data

Corroboration of the elevations listed in Table H-1 is provided by the extraction of surface elevations from a Digital Elevation Model (DEM) (DTN: SN0601SRTMDTED.001 [DIRS 177242]) using the UTM coordinates provided in Table H-1 as input. The DEM data were collected from a space shuttle radar survey. The UTM coordinates, Zone 11, NAD27 were provided to a GIS Analyst who then extracted the land surface elevations at those locations from the DEM. The coverage in the shuttle radar topography elevations were imported to the software code EARTHVISION V5.1 (see Section 3.2). Elevations were extracted by the DEM method using EARTHVISION on a PC using the IRIX 6.5 operating system. The output from EARTHVISION provides elevations to the nearest surveyed point of the specified coordinates. The site locations were located with EARTHVISION returning several surveyed elevation points. The EARTHVISION output elevations are compared to the elevations listed in Table H-1. The results of that extraction are provided in Table H-6. Note that the DEM-extracted elevations are provided in meters. The conversion from meters to feet was performed by dividing the value in meters by 0.3048 and rounding to the nearest foot. The difference between the extracted elevations and those provided in Table H-5 are under the column labeled "Absolute Difference in Elevation."

Table H-6. Land Surface Elevations of Six Meteorological Monitoring Sites Extracted Using a Digital Elevation Model and UTM Coordinates as Inputs

Site	UTM Coordinates, NAD27 Zone 11 (m)	Elevation from Table H-1	DEM derived Elevation [(a)]	Average-Absolute Difference in Elevation
Site 1 (NTS-60)	550,784E 4,077,374N	3,750 ft 1,143 m	3,753 ft 1,147 m	12 ft 4 m
Site 2 (Yucca Mountain)	547,646E 4,078,753N	4,850 ft 1,478 m	4,833 ft 1,478 m	0 ft 0m
Site 3 (Coyote Wash)	548,874E 4,078,710N	4,195 ft 1,279 m	4,190 ft 1,285 m	20 ft 6m
Site 6 (WT-6)	549,388E 4,083,097N	4,315 ft 1,315 m	4,304 ft 1,315 m	0 ft 0 m
Site 8 (Knothead Gap)	551,161E 4,075,773N	3,710 ft 1,131 m	3,684 ft 1,126 m	11 ft 5 m
Site 9 (G-510)	553,418E 4,058,398N	2,750 ft 838 m	2,766 ft 840m	6 ft 2m

[(a)] Elevations derived using data from DTN: SN0601SRTMDTED.001 [DIRS 177242] projected with EARTHVISION V5.1.

The comparison to the DEM-extracted elevations is within 0 to 6 meters for all monitoring sites. This difference is to be expected given that DEM elevations are not pin-point measurements, reflective of rugged topographic relief, but rather smoothed horizontal planar elevations. The varied topography of the Yucca Mountain site produces rapid elevation changes over relatively small lateral distances. The largest difference of 6 m falls within the established criterion of 20 m, and is within the horizontal resolution of the survey. If the coordinate values were in error by a significant amount, it would be unlikely that the elevations would match as well as they do. Thus, the elevations derived using DEM extraction corroborate the 1992-1993 GPS values listed in Table H-2. Additionally, the favorable comparison of the elevations also corroborates the geographic coordinates.

H.4 DISCUSSION AND CONCLUSION OF THE DATA CORROBORATION

The geographic coordinate values for the meteorological monitoring sites provided in Table A-1 of *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722]), and listed in Table H-1 of this appendix, have been corroborated using a variety of records and approaches. The data qualified via this analysis are the geographic coordinates for Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9 in the Nevada State Plane (NAD27 – feet), Universal Transverse Mercator (Zone 11, meters, NAD27), and longitude/latitude (NAD27) coordinate systems, and land surface elevation (NGVD 29 in meters and feet).

The meteorological site locations were corroborated using surveys derived from several sources. These surveyed data are presented in Tables H-2 and H-3 and are compared with values in Table H-1. The comparison confirm that the Nevada State Plane, longitude–latitude and elevation (in feet and meters), when rounded appropriately, compared favorably to values given in Table H-1.

Nevada State Plane and latitude and longitude coordinates for Sites 1, 2, 3, 6, 8, and 9 listed in Table H-1 (BSC 2006 [DIRS 176722], Table A-1) are corroborated with the 1992-1993 REECo survey (Azhikakath 1993 [DIRS 178473]), agree exactly, and thus are within the spatial tolerance (of 27 m) specified in this analysis.

Corroboration of Sites 1, 2, and 3 Nevada State Plane coordinates with the 1985 (Holmes & Narver 1985 [DIRS 178474]) layout coordinates is within the spatial tolerance of 27 m specified in this analysis. However, the fact that the 1985 coordinates are layout locations, and not necessarily the actual location, implies that the discrepancy between the two sets of coordinates may be the combined effects of errors in surveying and any difference between the planned and actual location of the monitoring site. The similarity between the two sets of coordinates provides additional confidence in the surveyed locations as noted in Tables H-1 and H-2.

Corroboration of the longitude and latitude coordinates for Sites 2, 6, 8, and 9 with the preliminary 1992 GPS survey (CRWMS M&O 1992 [DIRS 178475]) does fall outside spatial tolerance of 27 m. However, as noted above, the GPS results recorded in 1992 and listed in Table H-3 may be in error by as much as 30 m simply because the data were recorded to the nearest second of latitude or longitude. Nonetheless, the 1992 GPS data and the locations in Table H-1 are still quite similar. Therefore, the 1992 GPS survey data also corroborate the locations as presented in Table H-1.

All the site elevations are corroborated to the 1992-1993 REECo GPS survey. An additional corroboration was conducted using a DEM to extract the elevation at each of the monitoring site locations. The inputs used in the DEM-extracted elevations are the UTM coordinates for each site, provided in Table H-1. Using these coordinates as input, the DEM returns a corresponding elevation. The difference between the elevations extracted with the DEM method and those given in Table H-1 is 6 m or less.

In summary, the geographic location coordinates for all the sites listed in Table H-1 are considered to be accurate with at most a 27-meter error in the horizontal direction. The elevations for Sites 1, 2, 3, 6, 8, and 9 are considered to be accurate within 6 m in the vertical direction. Future users of the data should be aware of these accuracy tolerances.

The conclusion from this qualification is that the geographic “horizontal” coordinates for meteorological monitoring Sites 1, 2, 3, 6, 8, and 9 presented in Table H-1 are qualified, with the above caveats. The elevations for meteorological monitoring Sites 1, 2, 3, 6, 8 and 9 presented in Table H-1 are considered qualified. The qualified geographic coordinates and elevations are presented in Table H-6 and are part of output DTN: SN0612GEOCOORD.001.

Table H-7. Geographic Coordinates and Elevations for Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9

Site	UTM Coordinates, NAD27 Zone 11 (m)	Nevada State Plane Coordinates (ft)	Longitude–Latitude (deg° min' sec'')	Elevation (above mean sea level)
Site 1 (NTS-60)	550,784E 4,077,374N	569,126E 761,795N	116°25'50''W 36°50'34''N	3,750 ft 1,143 m
Site 2 (Yucca Mountain)	547,646E 4,078,753N	558,844E 766,356N	116°27'56''W 36°51'19''N	4,850 ft 1,478 m
Site 3 (Coyote Wash)	548,874E 4,078,01710N	562,874E 766,171N	116°27'06''W 36°51'17''N	4,195 ft 1,279 m
Site 6 (WT-6)	549,388E 4,083,097N	564,612E 780,592N	116°26'45''W 36°53'40''N	4,315 ft 1,315 m
Site 8 (Knothead Gap)	551,161E 4,075,773N	570,344E 756,538N	116°25'35''W 36°49'42''N	3,710 ft 1,131 m
Site 9 (G-510)	553,418E 4,058,398N	577,554E 699,491N	116°24'08''W 36°40'17''N	2,750 ft 838 m

Source: Output DTN: SN0612GEOCOORD.001.

Sandia National Laboratories

Data Qualification Plan

Complete only applicable items.

QA: QA
Page 1 of 1

Section I. Organizational Information

Qualification Title

Qualification of Geographic Coordinates and Elevations of Yucca Mountain Meteorological Monitoring Sites 1, 2, 3, 6, 8, and 9

Requesting Organization

Performance Assessment / Natural Systems

Section II. Process Planning Requirements

1. List of Unqualified Data to be Evaluated

Location data (spatial coordinates and elevation) for the Yucca Mountain Meteorological Monitoring Sites (site numbers 1, 2, 3, 6, 8, and 9) as presented in Table A-1 of the Technical Work Plan for Meteorological Monitoring and Data Analysis (TWP-MGR-MM-000001 Rev 03).

2. Type of Data Qualification Method(s) [Including rationale for selection of method(s) (Attachment 3) and qualification attributes (Attachment 4)]

The method chosen to qualify this data is corroborating data. The data in the table will be corroborated with GPS survey records from 1993 and with older survey data from 1985 and 1992 as well as an additional survey for one of the six (6) sites available from 1997. In addition, elevations at the weather station sites will be corroborated with elevations obtained from a digital elevation model (DEM).
The qualification attributes to be used are: 1) the extent to which the data demonstrate the properties of interest, and 2) extent and quality of corroborating data.

3. Data Qualification Team and Additional Support Staff Required

Qualification Chairperson – Kathleen Economy
Team Member – Kenneth Rehfeldt

4. Data Evaluation Criteria

The coordinate data qualified in this analysis are to be used in two ways: 1) to plot the location of the weather stations on a map to give the reader a sense of the location and distribution of climate data collection sites, and 2) to plot mean or median precipitation and temperature as a function of data collection site elevation to perform lapse rate calculations. For the purposes of plotting the data on a map printed on an 8.5 x 11 inch page, an error in the location of 0.01 inch is considered acceptable on the figure. At the scale of the maps in the document (the smallest scale is 2.7 km per inch), an error of 0.01 inch is equal to a coordinate error of 27 m. Therefore the spatial coordinates are considered corroborated if the values are less than 27 m apart. For elevation, the criterion is determined by examining figures in the document where elevation of the measurement site is plotted and used in a linear regression analysis. In all cases, the regression was reformulated to treat elevation as the dependent variable. When the regression is performed, it is possible to then identify the standard error of the Y estimate. When elevation is plotted versus precipitation, the standard error of the elevation estimate is greater than 135 m. When elevation is plotted versus temperature, the standard error of the elevation estimate is about 20 m. Assuming the differences in elevation are random, i.e. some are high and some are low, then a difference in elevation of 20 meters is considered acceptable for the purpose of this analysis report.

5. Identification of Procedures Used

The procedures used for this analysis for qualification of the data are SCI-PRO-001 (Qualification of Unqualified Data) and SCI-PRO-005 (Scientific Analysis and Calculations).

Section III. Approval

Qualification Chairperson Printed Name	Qualification Chairperson Signature	Date
Kathleen Economy	Kathy Economy	11/30/2006
Responsible Manager Printed Name	**Responsible Manager Signature**	**Date**
Stephanie Kuzio	[signature]	11/30/2006

SCI-PRO-001.1-R0

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